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CALIFORNIA REGIONAL $PM_{10}/PM_{2.5}$ AIR QUALITY STUDY (CRPAQS) ANCHOR SITE MEASUREMENTS AND OPERATIONS

FINAL REPORT
STI-999231-2332-FR

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ACKNOWLEDGMENTS

CRPAQS was a cooperative study involving dozens of individuals and organizations. The efforts of Sonoma Technology, Inc. in operating the Anchor measurement sites were dependent on the efforts of many of the other study team members.

The study was sponsored by the San Joaquin Valleywide Study Agency. We benefited greatly from the coordination and guidance provided by Karen Magliano of the California Air Resources Board who served as CRPAQS Project Manager and John Watson of Desert Research Institute (DRI), CRPAQS Principal Investigator.

The monitoring sites were selected and set up by Chuck McDade of ENSR, CRPAQS Field Program Manager, with help from David Wright. The instruments were selected and many of the Standard Operating Procedures (SOPs) were written by the measurement experts listed in Section 1 of this report, and the sites were operated by the field staff also listed in Section 1.

The filter, impactor and VOC samplers operated by STI were provided by DRI, Oregon Graduate Institute, and Atmospheric Assessment Associates, Inc. (AtmAA). These organizations provided SOPs for their samplers, assisted in setting up and troubleshooting the samplers, and performed the chemical analyses of the collected samples. Additional assistance in the program was provided by Technical and Business Systems, Inc., the Satellite site contractor, and by David Bush of Parsons Engineering, the Quality Assurance contractor.

We greatly appreciated the contributions and assistance of all the CRPAQS participants and thoroughly enjoyed the outstanding cooperation and teamwork of both the sponsors and participants.

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1. INTRODUCTION TO CRPAQS AND ANCHOR SITE OPERATIONS

1.1 CRPAQS OBJECTIVES AND OVERVIEW

The California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS) is a multi-year program of meteorological and air quality monitoring, emission inventory development, data analysis, and air quality simulation modeling. CRPAQS was designed to elucidate the nature and causes of particle concentrations and visibility impairment in and around central California, with a focus on the San Joaquin Valley (SJV).

The objectives of CRPAQS are to (1) provide an improved understanding of emissions and the dynamic atmospheric processes that influence particle formation and distribution, (2) develop and demonstrate methods useful to decision makers in formulating and comparing candidate control strategies for attaining the federal and state $PM_{10}/PM_{2.5}$ standards in central California, and (3) provide reliable means for estimating the impacts of control strategy options developed for $PM_{10}/PM_{2.5}$ on visibility, air toxins, and acidic aerosols and on attainment strategies for other regulated pollutants, notably ozone.

Meeting these objectives requires an extensive, high-quality air quality and meteorological database. Data for the study were obtained during a 14-month field program from December 1999 through January 2001. The field program included a long-term monitoring component (the “Annual” measurements) and more intensive seasonal measurements during summer, fall, and winter periods. A field monitoring plan (Watson et al., 1998) describes the planned monitoring objectives, activities, and network.

Air quality sampling sites included heavily instrumented “Anchor” monitoring sites measuring both gaseous and aerosol species, supplemental “Satellite” sites measuring aerosol species using portable filter samplers and integrating nephelometers, two tall towers with multiple levels of air quality instrumentation, and a “backbone” network of existing California Air Resources Board (ARB) and air pollution control district monitoring sites. The Environmental Protection Agency (EPA) Fresno Supersite was also located in the study domain and had instrumentation comparable to several of the CRPAQS anchor sites. The Supersite was operated by Desert Research Institute (DRI).

Surface and aloft meteorological measurements were made daily using a network of ground-level measurement instruments, radar profilers, sodars, and instruments located on tall towers. “Supplemental” data were obtained from non-CRPAQS networks operated by more than a dozen agencies in the region.

This report describes the measurements and operations at the ground-level and tower Anchor sites. These sites were operated by Sonoma Technology, Inc. (STI). The Anchor-site locations, measurements, study periods, and staff are presented in the remainder of Section 1. The measurement methods, sampler installations, site characteristics, operational procedures, quality assurance activities, and sources of additional CRPAQS information are described in subsequent sections of this report.

1.2 ANCHOR SITE LOCATIONS AND PARAMETERS MEASURED

The Anchor-site locations and the seasonal study periods during which the sites were operated are listed in **Table 1-1.** Latitude and longitude were measured using a Global Positioning System (GPS), and elevations were determined from a topographical map relative to sea level. The locations of the anchor sites are also depicted in **Figure 1-1.** The site layouts, surroundings, buildings, and other characteristics have been described in detail by McDade (2002). Site characteristics that could affect air quality measurements are also described in Section 3 of this report.

The measurements made at each Anchor site are listed in **Table 1-2.** Most of these measurements were made and reported by STI and its subcontractors. Some measurements were made by contractors who were making the same measurements at other locations or by the research teams who provided the measurement instrument. The nephelometers, Minivols, and hydrocarbon samplers noted in Table 1-2 by superscript "a" were operated by T&B Systems, the satellite site operations contractor (see Technical and Business Systems, Inc., 2002). The Aerosol Time of Flight Mass Spectrometer (ATOFMS) was operated by the University of California at Riverside.

Chemical analyses of samples collected by STI were performed and reported by other contractors. The filter, MOUDI, and heavy hydrocarbon (TENAX cartridge) analyses were performed by DRI. Light hydrocarbon (canister sample) analyses were performed by Oregon Graduate Institute (OGI). Aldehyde (DNPH cartridge) samples were analyzed by Atmospheric Assessment Associates, Inc. (AtmAA).

The instrument types and measurement methods used by STI are described in Section 2, and the operational procedures are discussed in Section 4. The specific instruments (serial numbers and operational dates) operated at each Anchor site are listed in Section 3.

Table 1-1. CRPAQS Anchor sites.

ID	Site	Address	Latitude [a] (degrees)	Longitude [a] (degrees)	MSL Elevation[b] (meters)	Study Period[d]			
						A	S	F	W
ALT1	Altamont Pass	Flynn Road Exit, I-580	37.718	-121.660	350[c]	x			
ANGI	Angiola trailer	36078 4th Avenue, Corcoran	35.948	-119.538	60	x			x
ANGT	Angiola tower (3 heights: ANG1, ANG50, ANG95)	36078 4th Avenue, Corcoran	35.948	-119.538	61, 110, 155	x			x
BAC	Bakersfield, California Avenue	5558 California Avenue #430, Bakersfield	35.357	-119.063	119	x			x
BODB	Bodega Bay	Bodega Marine Lab, 2099 Westside Road, Bodega Bay	38.319	-123.073	17				x
BTI	Bethel Island	5551 Bethel Island Road, Bethel Island	38.006	-121.642	2				x
COP	Corcoran, Patterson	1520 Patterson Ave., Corcoran	36.102	-119.566	63			x	
EDW	Edwards Air Force Base	Rawinsonde Road, Edwards Air Force Base	34.929	-117.904	724		x		
FSF	Fresno Supersite	3425 First Street, Fresno	36.781	-119.772	97	x			
M14	Modesto, 14th St.	814 14th Street, Modesto	37.634	-120.994	28				x
SDP	Sacramento, Del Paso Manor	2700 Maryal Drive, Sacramento	36.614	-121.368	26	x			x
SJ4	San Jose, 4th Street	120 N. 4th Street, San Jose	37.340	-121.889	26	x			
SNFH	Sierra Nevada Foothills	31955 Auberry Road, Auberry	37.063	-119.496	589[c]				x
WAG/ WAGT	Walnut Grove tower (10 m msl, 245 m msl)	KCRA-TV tower, Walnut Grove	38.264	-121.491	10, 245				x

[a] Coordinates are referenced to the NAD83 map datum .
[b] MSL elevation for all sites besides mountain sites is +/- 1 meter.
[c] MSL elevation for mountain sites is +/- 5 meters.
[d] A = Annual, S = Summer, F = Fall, W = Winter. Annual sites were operated for the entire study. Marks under S, F, or W for sites operated during the annual measurement period indicate that additional instruments were added to the sites for the seasonal studies.

Figure 1-1. CRPAQS Anchor site locations.

Table 1-2. Parameters measured at CRPAQS STI Anchor sites. (Sites denoted by an asterisk (*) were operated as Satellite sites during seasons when Aethalometers and other Anchor-site instruments were not operated. Seasons of operation are shown.)

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ID	Measured Parameter	ALT1	ANGI	ANG1	ANG50	ANG95	BAC	BODB*	BTI*	COP*	EDW*	M14*	SDP	SJ4	SNFH	WAG	WGT
A	Light Scattering (integrating nephelometer with “smart” heater)	A[a]	A	A	A	A	A	A[a]	A[a]	F[a] W[a]	A[a]	W[a]	A	A	A[a]	A[a]	W
B	$PM_{2.5}$ Mass, Elements, Ammonia (Minivol with Teflon & citric acid-impregnated cellulose filters; G, XRF, AC) (Annual = 6th day)	A[a] W[a]						A[a] W[a]	A[a]	A[a] W[a]	A[a]	A[a] W[a]			A[a]		
C	$PM_{2.5}$ Ions, Carbon, Nitric Acid (Minivol with quartz & NaCl-impregnated cellulose filters; IC, AC, TOR, AA) (Annual = 6th day)							A[a] W[a]	A[a]	A[a]	A[a]	A[a] W[a]			A[a]		
D	$PM_{2.5}$ Organic Compounds (Minivol with Teflon-coated Glass Fiber; GC/MS)		A[a]				A[a]		A[a]	A[a]	A[a]	A[a]	A[a]	A[a]	A[a]		
G-1	$PM_{2.5}$ Light Absorption (black carbon surrogate) (1-wavelength Aethalometer)[c]		A[b]				A[b]	W			S	W	A[b]	A[b]		W	W
G-2	$PM_{2.5}$ Light Absorption (7-wavelength Aethalometer)[d]		F, W			W	F, W		W	F			F, W	F, W	W		
H	$PM_{2.5}$ Organic & Elemental Carbon (Thermal oxidation)		A				A										
I-1	Particle Sizing, 0.3-10 µm		A		A	A											
I-2	Particle Sizing, 0.1-2 µm		A														
I-3	Particle Sizing, 0.01- 0.4 µm		A														
J	PM_{10} Mass (BAM)		A				A			F	S						
K	$PM_{2.5}$ Mass (BAM)	A	A				A		W	F	S		A	A	W		
L	$PM_{2.5}$ Mass, Elements, Ammonia (SFS with aluminum denuder, Teflon filters, & citric acid-impregnated cellulose backup filters; G, XRF)		A				A		W						W		
M	$PM_{2.5}$ Sulfate, Nitrate, Chloride, Potassium, Ammonium Ions, & OC/EC (SFS with aluminum denuder, quartz filter & NaCI-cellulose backup filter; IC, AA, AC, TOR)		A				A		W						W		
O	NO/NO_y (chemiluminescence)		A			W	A		W						W		

A = annual, S = summer, F = fall, W = winter.

AA = Atomic absorption, AC = Automated colorimetry, BAM = Beta attenuation monitor, DNPH = 2,4-di-nitro phenylhydrazine, FID = Flame ionization detector, G = Gravimetry, GC = Gas chromatography, HPLC = High pressure liquid chromatography, IC = Ion chromatography, MOUDI = Micro-Orifice Uniform Deposit Impactor, MS = Mass spectroscopy, OC/EC = Organic carbon/elemental carbon, OPC = Optical particle counter, PMS = Particle Measuring Systems, Inc., PUF/XAD = Polyurethane foam plug and polystyrene-divinylbenzene resin , SFS = Sequential Filter Sampler, SGS = Sequential Gas Sampler, SMPS = Scanning Mobility Particle Sizer, TOR = Thermal optical reflectance, TD = Thermal desorption, TSI = TSI Incorporated, XRF = X-ray fluorescence.

[a] These instruments were collocated at the Anchor sites but were not operated by STI. The nephelometers, Minivols, and hydrocarbon sampler noted were operated by T&B Systems (see Technical and Business Systems, Inc., 2002), which was the satellite site contractor. The Aerosol Time of Flight MS was operated by U.C. Riverside. B and C measurements labeled “W” were operated for 24 hours on winter IOP days.
[b] These instruments were replaced with 7-wavelength Aethalometers at the beginning of the fall study period.
[c] $PM_{2.5}$ light absorption @ 880nm.
[d] $PM_{2.5}$ light absorption @ 950nm, 880nm, 660nm, 590nm, 571nm, 450nm, 350nm.

Table 1-2. Parameters measured at CRPAQS STI Anchor sites. (Sites denoted by an askerisk (*) were operated as Satellite sites during seasons when Aethalometers and other Anchor-site instruments were not operated. Seasons of operation are shown.

ID	Measured Parameter	ALT1	ANGI	ANG1	ANG50	ANG95	BAC	BODB*	BTI*	COP*	EDW*	M14*	SDP	SJ4	SNFH	WAG	WGT
P	O_3		A			W									W		
Q	$PM_{2.5}$ Nitrate		F, W			W	F, W		W	F				W	W	W	W
R	HNO_3		W												W		
T	$PM_{2.5}$ Sulfate		W				W										
U	Light Hydrocarbons (canister & GC/FID)		W					A[a]	W						W		
V	Heavy Hydrocarbons (Tenax cartridges; GC/TD/FID)		W						W						W		
W	$PM_{2.5}$ Organic Compounds (Teflon coated glass fiber filter, PUF/XAD cartridges; GC/MS)		W						W						W		
X	Aldehydes (DNPH cartridges; HPLC)		W						W						W		
Y	SO_2						W										
b	PAN/NO_2		W				F, W		W						W		
c	Sulfate, Nitrate, Ammonium Size Distribution, Mass; (MOUDI with Teflon substrate; G, IC, AC)		W														
d	OC/EC Size Distribution, Mass (MOUDI with aluminum substrate; TOR, G)		W														
e	Aerosol Time of Flight MS		W[a]														
g	PM_{10} Mass, Elements, Ammonia (Minivol with Teflon & citric acid-impregnated cellulose filters & G, XRF, AC)									A[a] F[a]		A[a]					
h	PM_{10} Ions, Carbon, Nitric Acid (Minivol with Quartz & NaCl-impregnated Cellulose filters & IC, AC, TOR, AA)									A[a] F[a]		A[a]					
i	Denuder-Difference HNO_3 (SGS with aluminum denuder & NaCl-impregnated cellulose filters)		W												W		
j	Denuder-Difference NH_3 (SGS with citric-acid-coated glass denuder & citric-acid-impregnated cellulose filters)		W												W		
DAS	Data Acquisition System		A				A	W	W	F	S	W	A	A	W	W	W

A = annual, S = summer, F = fall, W = winter.

AA = Atomic absorption, AC = Automated colorimetry, BAM = Beta attenuation monitor, DNPH = 2,4-di-nitro phenylhydrazine, FID = Flame ionization detector, G = Gravimetry, GC = Gas chromatography, HPLC = High pressure liquid chromatography, IC = Ion chromatography, MOUDI = Micro-Orifice Uniform Deposit Impactor, MS = Mass spectroscopy, OPC = Optical particle counter, PMS = Particle Measuring Systems, Inc., PUF/XAD = Polyurethane foam plug and polystyrene-divinylbenzene resin , SFS = Sequential Filter Sampler, SGS = Sequential Gas Sampler, SMPS = Scanning Mobility Particle Sizer, TOR = Thermal optical reflectance, TD = Thermal desorption, TSI = TSI Incorporated, XRF = X-ray fluorescence.

[a] These instruments were collocated at the Anchor sites but were not operated by STI. The nephelometers, Minivols, and hydrocarbon sampler noted were operated by T&B Systems, which was the satellite site contractor. The Aerosol Time of Flight MS (ATOFMS) was operated by U.C. Riverside.

1.3 CRPAQS ANCHOR-SITE STUDY PERIODS

The field program included a long-term monitoring component (the "Annual" measurements) and more intensive seasonal measurements during summer, fall, and winter periods. The Annual Anchor-site measurements were made at the five sites operated by STI (Table 1-2) and the Fresno Supersite operated by DRI. One site was upgraded to Anchor status for the summer study period, and another for the fall. Five sites were added or upgraded to Anchor status for the winter period. Additional instruments were also added to three of the Annual Anchor sites for the winter period.

The start and end dates of the annual and seasonal study periods are listed in **Table 1-3**. During these periods, various sites and instruments became operational at different times. The first two months of the annual study were primarily dedicated to site installation, procedure refinement, and instrument testing and debugging. For the most part, the network was operational for the one-year period from February 2000 through January 2001. The actual operational dates of the sites and instruments are listed in Section 3.

Table 1-3. CRPAQS study periods.

Study Periods	Start and End Dates
Annual	12/1/99 - 2/3/01
Summer	7/1/00 - 8/31/00
Fall	10/9/00 - 11/14/00
Winter	12/1/00 - 2/3/01

The annual measurements characterized the spatial, diurnal, and seasonal variations of PM concentrations and visibility impairment throughout the SJV and the surrounding area. These measurements provide a means to characterize the evolution and transport of high PM concentrations in the SJV, and they provide a context for the seasonal measurements. The Annual Anchor measurements were concentrated between Fresno and Bakersfield where the highest PM concentrations in the SJV are measured, although measurements were also made at the Sacramento, San Jose, and Altamont sites.

Continuous and semi-continuous aerosol measurements, with time resolution of 5 to 60 minutes, were made for $PM_{2.5}$ and PM_{10} mass, aerosol size distribution, $PM_{2.5}$ organic and elemental carbon, $PM_{2.5}$ nitrate and sulfate, $PM_{2.5}$ light absorption, and light scattering. Continuous aerosol precursor measurements of ozone, NO, NO_y, HNO_3, PAN/NO_2, and SO_2 were made with time resolution of 5 to 15 minutes. Daily 24-hr $PM_{2.5}$ filter samples were also collected at many Anchor sites throughout the year using Teflon and quartz filters.

During the summer study period, monitoring was extended into the Mojave Desert to better understand transport from the SJV to the desert and the causes of summertime haze in that region. Additional satellite sites were located along transport pathways, and the Edwards Air Force Base satellite site was upgraded to an Anchor site. For the upgrade, the original light-scattering instrument was supplemented with PM_{10} and $PM_{2.5}$ mass and $PM_{2.5}$ light absorption instruments. In addition, 24-hr-average filter samples of particulate organic compounds were collected at the Fresno Supersite every sixth day.

The fall study was designed to characterize the effects of nearby pollution sources on high PM_{10} concentrations in the central portion of the SJV (centered near Corcoran). For the fall study, the Corcoran Patterson Street Satellite site was upgraded to an Anchor site, and 25 additional satellite sites were deployed within and surrounding the city. For the upgrade, the original light extinction instrumentation was supplemented with continuous measurements of PM_{10} and $PM_{2.5}$ mass, $PM_{2.5}$ light absorption, and $PM_{2.5}$ nitrate.

The CRPAQS winter episodic field study took place from December 1, 2000, through February 3, 2001. For this period, special emphasis was placed on semi-continuous species-specific aerosol measurements to support both receptor and grid-based modeling approaches. Five satellite sites were upgraded to anchor site status, and three of the Anchor sites and the Supersite were supplemented with additional instruments (see Tables 1-1, 1-2). During this period, three- to four-day intensive operational periods (IOPs) were selected on a forecast basis for additional monitoring. The intent of the IOPs was to characterize the evolution of $PM_{2.5}$ concentrations and properties during winter episodes. The IOP dates were selected by the ARB Project Manager (Karen Magliano) and the CRPAQS Principal Investigator (PI) (Dr. John Watson) based on input from a forecast team. On IOP days, additional time-resolved PM samples, heavy- and light-hydrocarbon samples, and aldehyde samples were collected at selected sites to characterize the diurnal distribution of these species and the temporal evolution of the PM concentrations.

Fifteen IOP days were selected on a forecast basis during the winter study period. These IOP dates are listed in **Table 1-4.**

Table 1-4. Winter CRPAQS IOP days.

Episode Number	Number of IOP Days	Dates
1	4	12/15/00 - 12/18/00
2	3	12/26/00 - 12/28/00
3	4	1/4/01 - 1/7/01
4	4	1/31/01 - 2/3/01

1.4 CRPAQS ANCHOR-SITE MANAGEMENT AND PARTICIPANTS

CRPAQS was funded by the San Joaquin Valleywide Air Pollution Study Agency, a joint powers agency (JPA) formed by the nine counties in the SJV. On a day-to-day basis, the ARB was responsible for the management of the study and for contract oversight. The ARB Project Manager and principal ARB coordinator and contractor contact was Karen Magliano. Scientific and technical guidance for CRPAQS was the responsibility of the PI, Dr. John Watson of DRI. Field planning, logistical support, site acquisition and installation, and site documentation were performed by the Field Program Manager, Dr. Charles McDade of ENSR International (ENSR).

At STI, the Anchor-site contract management team included Dr. Donald Blumenthal as the PI, Dr. Paul Roberts as the Technical Coordinator (TC), Mr. Lyle Chinkin as the Program Manager (PM), Dr. Beth Wittig as the Field Manager (FM), and Ms. Hilary Hafner as the Data Manager. In addition, to provide adequate direction for the large number of specialized measurements made in CRPAQS, measurement experts were enlisted to help guide each type of measurement.

Dr. Blumenthal had overall responsibility for performance of the STI tasks and for interactions with the CRPAQS management. He worked with the CRPAQS PI, PM, and FM to develop a final scope for the Anchor-site measurements. He developed the STI organizational structure for the project and selected the STI staff and the measurement experts to fill the management roles. His responsibilities included monitoring all phases of the project to ensure that the milestones were met, resolving conflicts and problems as they arose, overseeing preparation of final reports, and trading off with the TC and PM as needed to ensure that a senior manager was always available for decision making and emergencies.

The ongoing technical activities of the project were coordinated by Dr. Roberts. He worked with the CRPAQS investigators and measurement experts to select the instruments used and specify their options. He directed the setup, testing, and training activities of the measurement experts and the setup contractors, as well as the field operations and data management activities. He also coordinated the project quality control (QC) activities and oversaw preparation of the Quality Integrated Work Plan (QIWP) (Wittig et al., 2000).

The business and financial activities of the project were managed by Mr. Chinkin. He was responsible for contract and schedule management, budget management, subcontracting, development and oversight of schedules, preparation of monthly reports and invoices, contract modifications, directing preparation of the Health and Safety Plan (HASP) (Wittig et al., 1999), and interacting with the ARB on budgetary and schedule issues.

The field operations activities were managed by Dr. Wittig. She worked with the measurement experts to assemble and revise the documentation necessary for operation of the measurement instruments. She managed the installation activities for the anchor-site instruments, trained the field technicians, and provided support at the sites. She compiled the QIWP and the HASP and authored or edited the standard operating procedures (SOPs) used during the study. She developed simplified operational instructions that facilitated instrument operation by site technicians instead of measurement experts. She set up a field headquarters in Bakersfield and managed the activities of the STI field staff, including resolving instrument, site, and field-personnel issues as they arose.

Ms. Hafner coordinated acquiring data from the sites on a daily basis, processing the data, reviewing the data for problems, performing Level 1A QC, and submitting the data reports. She also coordinated preparation of the final data management report.

For each measurement, an expert in that measurement was responsible for input to the QIWP; development of the SOPs and calibration and QC procedures; coordination of the preparation, setup, and installation of the measurement systems; training of the field staff for that instrument; suggestion of data-review criteria; periodic review of selected data to ensure the instruments were working properly; and input to the Data Quality Summary Reports and the Field Summary Report.

The measurement experts and their instrument responsibilities were as follows:

- Aethalometers – Dr. Beth Wittig (STI)
- Continuous carbon, sulfate, nitrate – Dr. Susanne Hering (Aerosol Dynamics, Inc., ADI)
- Continuous PM_{10} and $PM_{2.5}$ mass (BAM) – Dr. Paul Roberts (STI)
- Filter samplers and MOUDIs – Dr. Judy Chow (DRI)
- Integrating nephelometers – Dr. L. Willard Richards (STI)
- $NO/NO_{y,}$, PAN/NO_2, and nitric acid instruments – Mr. Dennis Fitz (U.C. Riverside College of Engineering-Center for Environmental Research and Technology , CE-CERT)
- Ozone – Dr. Paul Roberts (STI)
- Particle-size instruments – Dr. Susanne Hering (Aerosol Dynamics, Inc., ADI)
- SO_2 – Mr. Earle Wright (Harding ESE, ESE)
- VOC samplers (these were operated for DRI, OGI, and AtmAA) – Dr. Paul Roberts (STI)
- Data acquisition systems – Mr. Mark Stoelting (STI)

The organizational structure for the Anchor-site operations is shown in **Figure 1-2**. The key personnel and their roles are listed in **Table 1-5**.

CRPAQS MANAGEMENT
ARB Project Manager - Karen Magliano
Principal Investigator - John Watson (DRI)
Field Program Manager - Chuck McDade (ENSR)

SONOMA TECHNOLOGY, INC.
PROJECT MANAGEMENT
Principal Investigator - Donald L. Blumenthal
Technical Coordinator - Paul Roberts (STI)
Project Manager - Lyle Chinkin (STI)

Measurement Experts
Paul Roberts (STI)

Judy Chow (DRI)
Dennis Fitz (CE-CERT)
Susanne Hering (ADI)
Paul Roberts (STI)
L. Willard Richards (STI)
Mark Stoelting (STI)
Beth Wittig (STI)
Earle Wright (ESE)

Setup and Training
Beth Wittig (STI)

Nicole Hyslop (STI)
Mark Stoelting (STI)
Steven Ludewig (STI)
Earle Wright (ESE)
David Fields (Fields Tower Systems, FTS)
Measurement Experts and their Staffs

Field Operations
Field Manager – Beth Wittig (STI)

Nicole Hyslop (STI) – ALT1, BODB, SDP, SJ4
William Keifer (STI) - BTI
Matthew Meyers (STI) - BAC
Christopher Rumm (STI) - BODB, BTI, EDW, M14, SDP, SJ4
Peter San Juan (PES) - COP, ANGI
Mark Stoelting (STI) - WAGT
Wanda Sullivan (STI) - ANGI
Ryan Wheeler (STI) – WAG
Beth Wittig (STI) – ANGI, BAC
Earle Wright (ESE) - SNFH

Data Management & QC
Data Manager – Hilary Hafner (STI)

Siana Alcorn (STI)
Jerry Anderson (STI)
Eric Gray (STI)
Cindy Green (STI)
Carryl Hardy (STI)
Theresa O'Brien (STI)
Beth Wittig (STI)
(Measurement Experts and their staffs)

Figure 1-2. CRPAQS Anchor-site organizational structure.

Table 1-5. Organizations and individuals involved with the CRPAQS anchor sites.

Organization	Name	Role
ADI	Susanne Hering*	Nitrate/Sulfate/Aerosol Size-Distribution Measurements Expert
ADI	Brent Kirby	Nitrate/Sulfate operations and DP
ADI	Mark Stolzenburg	Size Distribution operations and DP
ARB	Greg O'Brien	CRPAQS Database Manager
ARB	Karen Magliano	CRPAQS Project Manager
AtmAA, Inc.	Kochy Fung	Aldehyde Measurements
CE-CERT	Dennis Fitz*	Nitrogenous Species Measurements Expert
CE-CERT	Kurt Bumiller	Nitrogenous Measurements
DRI	Barbara Zielinska	Heavy Hydrocarbon Measurements
DRI	John Watson	CRPAQS Principal Investigator
DRI	Judy Chow*	Filter Analyses
ENSR International	Chuck McDade	CRPAQS Field Program Manager
FTS	David Fields	Walnut Grove Tower equipment installation
OGI	Rei Rasmussen	Hydrocarbon Measurements
Parsons Eng. Science	Dave Bush	CRPAQS Quality Assurance Manager
PCR	Dave Wright	Assistant CRPAQS Field Program Manager
STI	Beth Wittig*	Anchor Site Field Manager
STI	Bill Kieffer	Bethel Island Site Operator
STI	Chris Rumm	Anchor Site Field Technician
STI	Cindy Green	Anchor Site Database Management
STI	Don Blumenthal	Anchor Site Principal Investigator
STI	Hilary Hafner	Anchor Site Database Manager
STI	Mark Stoelting*	Data Communications & Walnut Grove Tower Operator
STI	Matt Meyers	Bakersfield Site Operator
STI	Nicole Hyslop	Anchor Site Support
STI	Paul Roberts*	Anchor Site Technical Coordinator
STI	Steve Ludewig	Anchor Site Data Communications
STI	Wanda Sullivan	Angiola Site Operator
STI	L. Willard Richards*	Nephelometer Measurements
ESE	Greg Vetter	SNFH Holiday Site Operator
ESE/PES	Peter San Juan	Corcoran/Angiola Site Operator
STI/ESE/TMSI	Earle Wright*	SNFH Site Operator

* Measurement Experts

ADI = Aerosol Dynamics, Inc.
ARB = California Air Resources Board
AtmAA = Atmospheric Assessment Associates, Inc.
CE-CERT = University of California, Riverside College of Engineering-Center for Environmental Research and Technology
DRI = Desert Research Institute
ENSR = ENSR International
FTS = Fields Tower Services
OGI = Oregon Graduate Institute
PCR = PCR Services Corp.
STI = Sonoma Technology, Inc.
ESE = Environmental Science and Engineering. Inc., now Harding-ESE
PES = Pacific Environmental Services, now part of ESE
TMSI = Technical Monitoring Services Inc. – under subcontract to ESE

2. DESCRIPTION OF MEASUREMENTS

This section describes the measurement methods and instruments used by STI at the Anchor sites. The principals of operation, installation, sampling times for non-continuous instruments, operational issues, data acquisition, and calibration approaches are discussed.

2.1 OVERVIEW OF MEASUREMENT METHODS

The continuous measurement instruments used at the Anchor sites and their operational characteristics are listed in **Table 2-1**. The measurement expert who provided guidance on the operation of each instrument is also noted in this table. The continuous measurement instruments were operated continuously throughout their respective study periods (see Table 1-2) except for periods of malfunction.

Table 2-1. Continuous measurement instruments and operating characteristics.

ID	Measured Parameter	Vendor/Model	Method	Averaging Time (min)	Detection Limit	Response Time (min)	Measurement Expert
A	Light scattering	Radiance Research M903 Integrating Nephelometer	Visible light scattering	5	1 Mm^{-1}	0.5	Richards
G-1	$PM_{2.5}$ black carbon (1-wavelength)	Andersen Instruments AE1X Aethalometer	Light absorption @ 880 nm	5	0.035 µg/m^3	5	Alcorn
G-2	$PM_{2.5}$ black carbon (7-wavelength)	Andersen Instruments AE3X Aethalometer	Light absorption @ 950 nm, 880 nm, 660 nm, 590 nm, 571 nm, 450 nm, 350 nm	5	0.035 µg/m^3	5	Wittig
H	$PM_{2.5}$ OC/EC carbon	Rupprecht & Patashnick 5400 OC/EC	Thermal oxidation of C to CO_2; NDIR detection	60	2 µg/m^3	60	Wittig
I-1	Particle sizing 0.3-10 µm, 16 channels	Climet Instruments Spectro.3 CI-500 OPC	Optical particle sizing and counting	5	0.0002-0.04 #/cm^3 [(a)]	5	Hering
I-2	Particle sizing 0.1-2 µm, 8 channels	Particle Measuring Systems Lasair OPC	Optical particle sizing and counting	5	0.007-2 #/cm^3 [(b)]	5	Hering
I-3	Particle sizing 0.01-0.4 µm, 53 channels	TSI SMPS	Scanning mobility particle sizing and counting	5	1/cm^3	5	Hering
J	PM_{10} mass	Met One Instruments 1020 BAM	Beta ray attenuation	60	1 µg/m^3	60	Wittig
K	$PM_{2.5}$ mass	Met One Instruments 1020 BAM	Beta ray attenuation	60	1 µg/m^3	60	Wittig
O	NO/NO_y	Thermo Environmental Instruments 42CY NO_y	Chemiluminescence with single external converter	5	100 ppt	1.3	Fitz
P	O_3	Advanced Pollution Instrumentation 400A O_3	UV absorption at 254 nm	5	1 ppb	0.2	Wittig
Q	$PM_{2.5}$ nitrate	Rupprecht & Patashnick 8400N Nitrate	Thermal flash vaporization NO detection	10	0.3 µg/m^3	10	Hering
R	HNO_3	Thermo Environmental Instruments Dual Converter 42CY HNO_3	Chemiluminescence with dual external converters	5	100 ppt	1.3	Fitz
T	$PM_{2.5}$ sulfate	Rupprecht & Patashnick 8400S Sulfate	Thermal flash vaporization SO_2 detection	10	0.3 µg/m^3	10	Hering
Y	SO_2	Thermo Environmental Instruments 43S SO_2	Pulsed UV fluorescence at 294 nm	5	50 ppt	1	Wright
b	PAN/NO_2	CE-CERT PAN/NO_2	Continuous luminol with chromatography	15	0.5 ppb	1	Fitz

BAM = Beta attenuation monitor; CE-CERT = U.C. Riverside College of Engineering-Center for Environmental Research and Technology; NDIR= non-dispersive infrared; OC/EC = Organic carbon/elemental carbon; OPC = Optical particle counter; SMPS = Scanning Mobility Particle Sizer; TSI = TSI Incorporated; UV = Ultraviolet

[(a)] For bins 16 to 1, respectively
[(b)] For bins 8 to 1, respectively

The Anchor-site non-continuous measurements, methods, and sampling frequencies are summarized in **Table 2–2**. The sequential filter samplers and Minivols were used to collect non-continuous PM samples during the Annual Study at the Anchor sites. During the Winter Study, the sequential samplers were supplemented with an array of other PM and gas-phase samplers for use on Winter-Study IOP days. The responsibility of the STI field technicians was to load, operate, and unload the non-continuous samplers. The substrates were provided by other contractors who also performed the laboratory analyses of the substrates.

Table 2-2. Non-continuous samplers, analysis methods, and sampling frequencies.

ID	Measured Parameter	Collection Method	Analysis Method	Sampling-Day Frequency [a]
B[b]	$PM_{2.5}$ mass, elements, ammonia	Minivol with Teflon and citric acid-impregnated cellulose filters	Gravimetry, XRF, AC	Annual 6th day, Winter IOP days at ALT, BODB, COP, M14
C[b]	$PM_{2.5}$ ions, carbon, nitric acid	Minivol with quartz and NaCl-impregnated cellulose filters	IC, AC, TOR, AA	Annual 6th day, Winter IOP days at BODB, M14
D[b]	$PM_{2.5}$ organic compounds	Minivol with Teflon-coated glass fiber filter	GC/MS	Annual 6th day
L	$PM_{2.5}$ mass, elements, ammonia	DRI SFS with aluminum denuder, Teflon filters, and citric acid-impregnated cellulose filters	Gravimetry, XRF, AC	Annual daily, Winter IOP days
M	$PM_{2.5}$ ions and carbon	DRI SFS with aluminum denuder, quartz filter, and NaCl-impregnated cellulose backup filter	IC, AA, AC, TOR	Annual daily, Winter IOP days
U	Light hydrocarbons	OGI canister	GC/FID	Winter IOP days
V	Heavy hydrocarbons	DRI TENAX	GC/TD/FID	Winter IOP days
W	$PM_{2.5}$ organic compounds	DRI Teflon coated glass fiber filter; PUF/XAD cartridge	GC/MS	Winter IOP days
X	Aldehydes	AtmAA DNPH	HPLC	Winter IOP days
c	Ion size distribution	DRI MOUDI with Teflon substrates, 0.1-15 µm, 9 cuts	IC, AC, Gravimetry	Winter IOP days
d	Carbon size distribution	DRI MOUDI with aluminum substrates, 0.1-15 µm, 9 cuts	TOR, Gravimetry	Winter IOP days
g[b]	PM_{10} mass, elements, ammonia	Minivol with Teflon and cellulose/citric acid filters	Gravimetry, XRF, AC	Annual 6th day, Fall IOP – daily at Corcoran
h[b]	PM_{10} ions, carbon, nitric acid	Minivol with quartz and NaCl-impregnated cellulose filters	IC, AC, TOR, AA	Annual 6th day, Fall IOP – daily at Corcoran
i	Denuder-difference HNO_3	DRI SGS with aluminum denuder and NaCl-impregnated cellulose filters	IC	Winter IOP
j	Denuder-difference NH_3	DRI SGS with citric-acid-coated glass denuder and citric-acid-impregnated cellulose filters	AC	Winter IOP

AA = Atomic absorption; AC = Automated colorimetry; AtmAA = Atmospheric Assessment Associates; Inc.; DNPH = 2;4-di-nitro phenylhydrazine; DRI = Desert Research Institute; FID = Flame ionization detector; GC = Gas chromatography; HPLC = High pressure liquid chromatography; IC = Ion chromatography; IOP = Intensive operational period; MOUDI = Micro-Orifice Uniform Deposit Impactor; MS = Mass spectroscopy; OGI = Oregon Graduate Institute; PUF/XAD = Polyurethane foam plug and polystyrene-divinylbenzene resin ; SFS = Sequential Filter Sampler; SGS = Sequential Gas Sampler; TOR = Thermal optical reflectance; TD = Thermal desorption; XRF = X-ray fluorescence.

[a] Annual daily samples were collected for 24h; Winter IOP samples were collected on the schedules summarized in Table 2-3.
[b] These instruments were collocated at Anchor sites, but were operated by T&B Systems, which was the satellite site contractor (see Technical and Business Systems, Inc., 2002).

The non-continuous PM measurements were made using samplers that did not operate throughout the entire study period, but instead followed a pre-defined schedule that is also presented in this section. Sampler schedules varied depending upon whether there was an intensive operation.

The number of samples per day and the sampling periods for all of the non-continuous samplers except for the MOUDI are listed in **Table 2-3**. Some of these schedules are different from those presented in the Program Plan (Watson et al, 1998) because of rescheduling to deal with logistical issues and staffing schedules. **Table 2-4** lists the sampling information for the MOUDI sampler. The MOUDI sampler was operated for non-contiguous sampling periods because of the long time needed to unload and reload the sampler.

Table 2-3. Non-continuous PM measurement sampling schedules.

ID	Measured Parameter	Sample Type	Samples Per Day	Sampling Times (PST)
B[a]	$PM_{2.5}$ mass, elements, ammonia (Minivol)	6th day IOP	1 1	0000-2400 0000-2400
C[a]	$PM_{2.5}$ ions, carbon, nitric acid (Minivol)	6th day IOP	1 1	0000-2400 0000-2400
D[a]	$PM_{2.5}$ organic compounds (Minivol)	6th day	1	0000-2400
L	$PM_{2.5}$ mass, elements, ammonia (SFS with aluminum denuder, Teflon filter, citric acid-impregnated cellulose filter)	Daily IOP	1 5	0000-2400 0000-0500, 0500-1000, 1000-1300, 1300-1600, 1600-2400
M	$PM_{2.5}$ ions & carbon (SFS with aluminum Denuder, quartz filter, NaCl cellulose)	Daily IOP	1 5	0000-2400 0000-0500, 0500-1000, 1000-1300, 1300-1600, 1600-2400
U	Light hydrocarbons (canister)	IOP	4	0000-0500, 0500-1000, 1000-1600, 1600-2400
V	Heavy hydrocarbons (TENAX cartridge)	IOP	4	0000-0500, 0500-1000, 1000-1600, 1600-2400
W	$PM_{2.5}$ organic compounds (Teflon coated glass fiber filter; PUF/XAD cartridge)	IOP	2	1600-0500 [b], 0500-1600
X	Aldehydes (DNPH cartridge)	IOP	4	0000-0500, 0500-1000, 1000-1600, 1600-2400
c	Ion size Distribution (MOUDI with Teflon)	IOP	1 - 2	0000-0500, 0500-1000, 1000-1600, 1600-2400 [c]
d	Carbon size distribution (MOUDI with aluminum)	IOP	1 - 2	0000-0500, 0500-1000, 1000-1600, 1600-2400 [c]
g[a]	PM_{10} mass, elements, ammonia (Minivol)	6th day Fall IOP	1 1	0000-2400 0000-2400
h[a]	PM_{10} ions, carbon, nitric acid (Minivol)	6th day Fall IOP	1 1	0000-2400 0000-2400
i	Denuder-difference HNO_3 (SGS)	IOP	5	0000-0500, 0500-1000, 1000-1300, 1300-1600, 1600-2400
j	Denuder-difference NH_3 (SGS)	IOP	5	0000-0500, 0500-1000, 1000-1300, 1300-1600, 1600-2400

DNPH = 2,4-di-nitro phenylhydrazine; IOP = Intensive operational period; MOUDI = Micro-Orifice Uniform Deposit Impactor; SFS = Sequential Filter Sampler; SGS = Sequential Gas Sampler

[a] These instruments were collocated at Anchor sites but were operated by T&B Systems, which was the satellite site contractor (see Technical and Business Systems, Inc., 2002).
[b] Sample collection began the day before the IOP at 1600 PST.
[c] Only one or two samples of the four listed were collected on any given IOP day. The time periods of the collected samples were based on the episode day number and were defined by the CRPAQS P.I.

Table 2-4. MOUDI sampling schedule.

IOP Day	Winter IOP Sampling Times (PST)			
	0000-0500	**0500-1000**	**1000-1600**	**1600-2400**
1		X		
2	X		X	
3		X		X
4			X	
5	X			X
6			X	
7		X		X
8			X	
9	X			
10	X		X	
11		X		X
12			X	
13		X		
14	X		X	
15		X		X
Total	**5**	**6**	**7**	**5**

Some measurements and measurement techniques that were initially identified in the Program Plan were changed because of operational and cost considerations. For example, the measurement of the hydroxyl radical was dropped because a reliable technique for this measurement had not been developed by the start date of the field study. Also, the total mass measurement was initially specified to be made by a Tapered Element Oscillating Microbalance (TEOM), but due to biases in the measurements made by TEOMs in high RH conditions, the BAM was used instead.

2.2 INSTRUMENT AND SAMPLER INSTALLATION

We tried to install the CRPAQS Anchor-site instruments in a consistent fashion from site to site, even at sites with considerable space limitations. Consistent installation was important to minimize sampling biases at a single site and across sites. Guidelines used for installation of the Anchor-site instruments are summarized below. These guidelines were followed whenever possible; however, some exceptions were made because of space availability. Nonstandard installations were designed to minimize adverse effects.

The Anchor-site setup and inlet design and installation were cooperative efforts between STI and ENSR. The sites were acquired and prepared by ENSR. Site photographs and additional information on site layout and instrument locations are provided by McDade (2002).

2.2.1 Continuous Instruments

Most of the continuous instruments were housed in the Anchor-site buildings and drew their sample air from inlets on the roofs. Platforms were built on or over the roofs to provide access to the inlets and rooftop samplers. Two exceptions were the Integrating Nephelometers and the tower instruments. The Anchor-site nephelometers were installed outside on the roof platforms in their own enclosures to be consistent with the Satellite-site installations (see Section 2.3.1). The Angiola ground-level nephelometer and the Walnut Grove nephelometers were also installed outside in the same types of enclosures. The remaining tower instruments were installed in fiberglass enclosures on the Angiola Tower and in steel enclosures on the Walnut Grove tower. Those instruments sampled from the sides or tops of the enclosures. The guidelines for the construction and installation of the Anchor-site inlets include the following.

- Inlet height – All instrument inlets sampled from at least 1.75 m (6 ft) above the roof of the building or trailer housing the site. This guideline was established to minimize sampling biases as a result of sampling within the boundary layer of the sampling station.
- Spacing between inlets – Unofficial EPA guidance is that the inlets of instruments with a flow rate above 100 LPM should be separated by =2 m (6.5 ft). None of the CRPAQS Anchor-site instruments sampled above 16.67 LPM, so we chose a smaller separation distance. The inlets of instruments with a flow rate above 6 LPM were separated by at least 1.25 m (4 ft). This guidance was established to minimize sampling biases as a result of a nearby instrument.
- PM inlet configuration – The PM inlets and sampling lines were designed to minimize sample losses in the lines. Except for the PM_{10} BAM and the OPCs, all the continuous instruments had a 2.5 µm cut device at the inlet of the sample lines. The PM_{10} BAM and the OPCs were cut at 10 µm. The BAMs, the OC/EC, and the Climet OPC had straight-line drops from inlet to instrument. The Lasair and SMPS particle sizing devices sampled from the Climet inlet line using conductive tubing with several 90° bends; however, they sampled particles under 2 µm, and line-loss calculations were performed that showed insignificant wall losses in the lines. The sulfate and nitrate samplers had up to four 90° bends in the shelters, and the nitrate monitors on the Walnut Grove Tower had at least one 90° bend. The Aethalometers sampled from the back and also required at least one 90° bend. Line loss calculations were performed for these instruments as well, and the losses were shown to be acceptable.
- PM inlet material – All PM instrument inlets were aluminum. If aluminum tubing was not provided by the manufacturer, refrigeration tubing was used instead. ABS and conductive rubber tubing were used in conjunction with the aluminum tubing to make the physical connection between the inlet and the instrument. Aluminum was used to minimize line losses of PM as a result of wall losses due to by charge mobility. The use of aluminum raises questions about loss of nitrate due to scrubbing of nitric acid gas by the aluminum and the subsequent loss of particle nitrate due to reestablishing of equilibrium. The residence time in the inlet tubes was determined to be short enough that this effect should be minimal.
- Gas-phase inlet configuration – The gas-phase instruments sampled from independent inlet lines. None of these instruments sampled above 4 LPM, so sampling bias as a result

of nearby instruments was not an issue. The inlets were relatively close to each other to minimize calibration line length. However, inlets were separated horizontally by at least 1.25 m (4 ft) so that calibration gases injected at the inlet of one instrument would not affect sampling of an adjacent instrument.

- Gas-phase inlet material – All gas-phase instrument inlet lines were PFA Teflon and faced downward. If the inlet outside diameter was 6.4 mm (1/4”) or smaller, funnels were used at the physical inlet to prevent drawing water into the inlet line. Any other component that the sampled air contacted was made of Teflon, including the wetted parts of solenoid valves and Swagelok fittings. This guidance was established to minimize sampling biases as a result of the further reaction of the sampled species.

2.2.2 Non-continuous Samplers

The non-continuous samplers collected grab samples for subsequent laboratory analyses. These samplers were located outside on the roofs of the shelters. The higher-volume (=16 l/m) samplers were separated by 2 m (6.5 ft), including the SFS, the SGS, the TENAX sampler, and the MOUDIs. The remaining samplers were separated by 1.25 m (4 ft) because of their low flow rates.

At the space-limited sites, these guidelines were difficult to follow, sometimes requiring the reorganization of instrument inlets at a pre-existing site.

2.2.3 Examples of Sampler Installations

Typical instrument installations are shown in the following photographs using the Angiola site as an example. **Figure 2-1** shows the overall layout of the site with the instruments on the roof of the trailer. **Figure 2-2** shows the height and spacing of the roof-mounted instruments and inlets. Detailed drawings of the layout are included in McDade (2002). **Figure 2-3** shows the instrument inlets inside the Angiola trailer. Most inlets were designed to drop straight down to the sampling instruments below.

Figure 2-1. Angiola trailer.

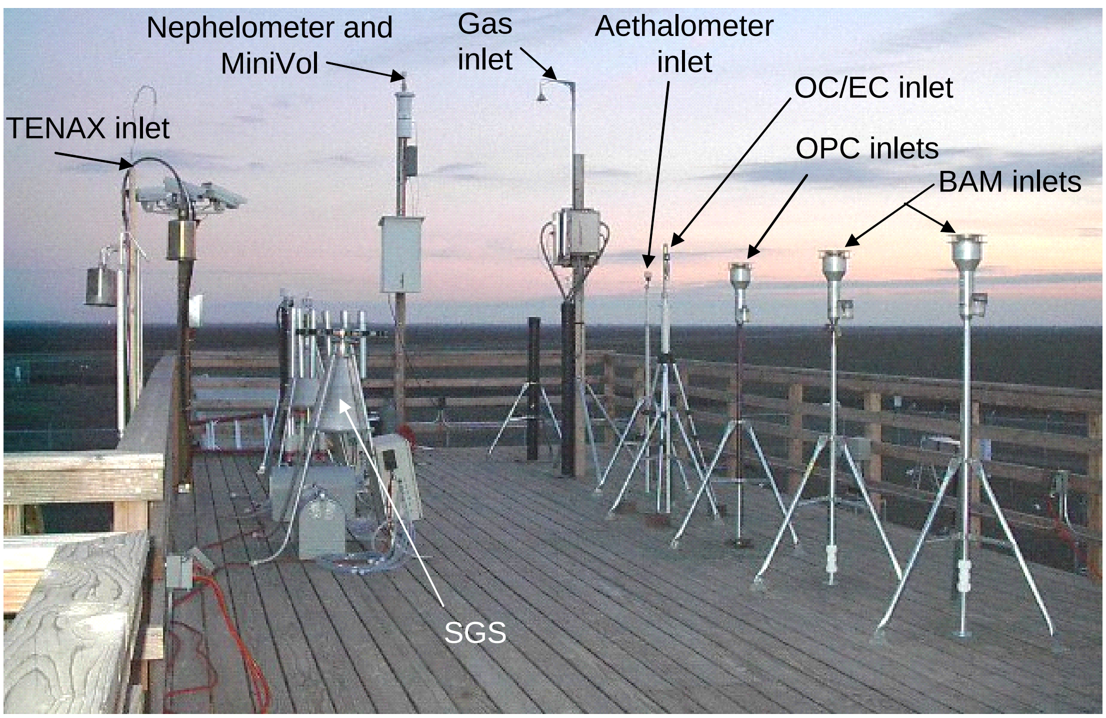

Figure 2-2. Angiola roof-mounted instruments and inlets.

Figure 2-3. Inlets to sampling instruments inside the Angiola Trailer.

Figure 2-4 shows a typical layout of the gas-phase instruments. From top to bottom, the rack contains the data acquisition system; NO_y, O_3, and HNO_3 monitors; and several calibration-system components. **Figure 2-5** shows the PAN/NO_2 system.

Figure 2-4. Angiola gas-phase instrument rack.

Figure 2-5. Angiola PAN/NO_2 monitor.

The inlets for the O_3, NO/NO_y, and HNO_3 monitor are shown in **Figures 2-6 and 2-7**. The O_3 inlet is at the top with a downward-facing funnel. The NO_y and HNO_3 converter boxes and inlets are below. Calibration gases are brought directly to the inlets from the calibrator or matrix air source through the lines shown in Figure 2-7.

Figures 2-8 to 2-14 illustrate typical installations of the continuous PM instruments including the BAM and OC/EC. Note the straight line drops from the PM_{10}/$PM_{2.5}$ inlets to the instrument inlets. The Aethalometer is an exception. The Aethalometers have a rear inlet that requires a 90° bend in the inlet line. The installation illustrated was typical for this instrument at all sites.

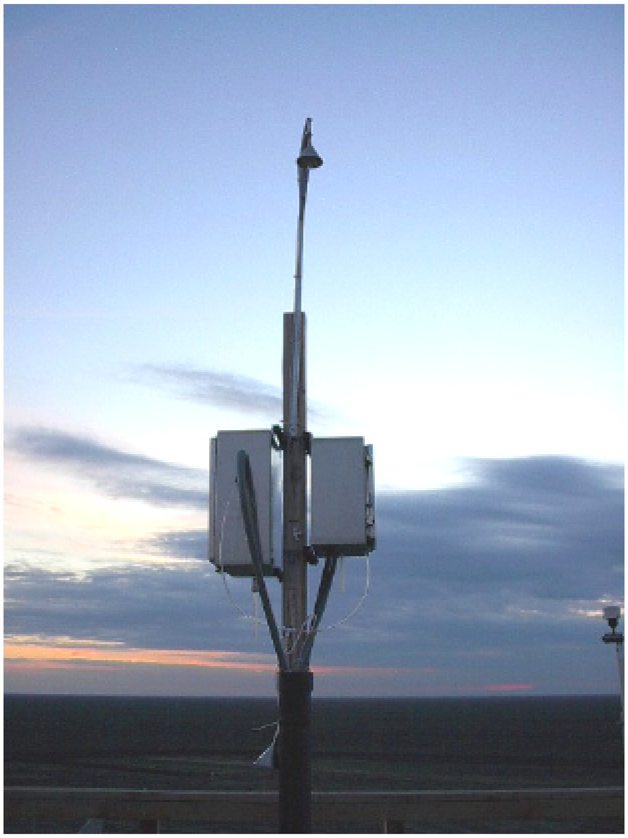

Figure 2-6. O_3, NO/NO_y, and HNO_3 inlets and converter boxes.

Figure 2-7. Tubing carrying calibration gases to sampler inlets.

Figure 2-8. $PM_{2.5}$ and PM_{10} Beta Attenuation Monitors (BAMs) and inlet tubes.

Figure 2-9. BAM PM_{10} and $PM_{2.5}$ inlets.

Figure 2-10. Organic/elemental carbon (OC/EC) monitor with inlet through ceiling. (Large duct is exhaust from high-temperature oven).

Figure 2-11. OC/EC $PM_{2.5}$ cyclone inlet.

Figure 2-12. Integrating Nephelometer enclosure for outside installations. (Photo by L.W. Richards, see Appendix A.2.)

Figure 2-13. Aethalometer with inlet through ceiling.

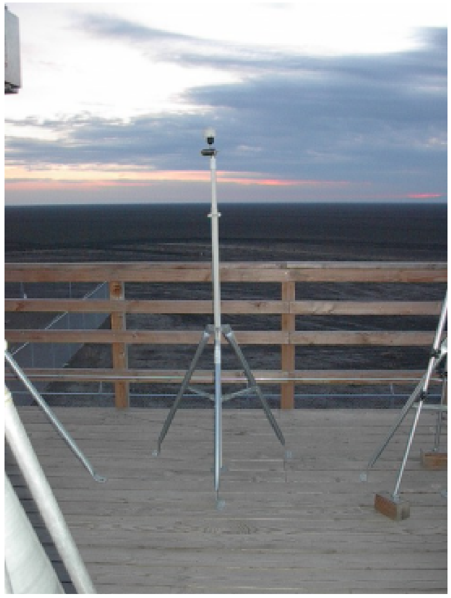

Figure 2-14. Aethalometer $PM_{2.5}$ cyclone inlet.

Figures 2-15 to 2-17 show installations of continuous PM instruments where a manifold instead of a straight-in sampling line was used. The nitrate, sulfate, and optical particle sizing systems at Angiola were installed using manifolds. In other installations, the nitrate, sulfate, and Climet OPC instruments sampled from independent inlets. The nitrate/sulfate manifold was insulated to prevent loss of nitrate through volatilization due to heating of the line in the trailer.

Figure 2-15. Nitrate and sulfate monitors showing insulated ducted inlets.

Figure 2-16. Common inlet for $PM_{2.5}$ nitrate and sulfate.

Figure 2-17 shows the particle sizing instruments and manifold. The photograph shows the straight-in inlet for the Climet and the black tubing that taps off of the inlet line to carry sample air to the Lasair and SMPS. A detailed description of the manifold is included in the SOP in Appendix A.5.

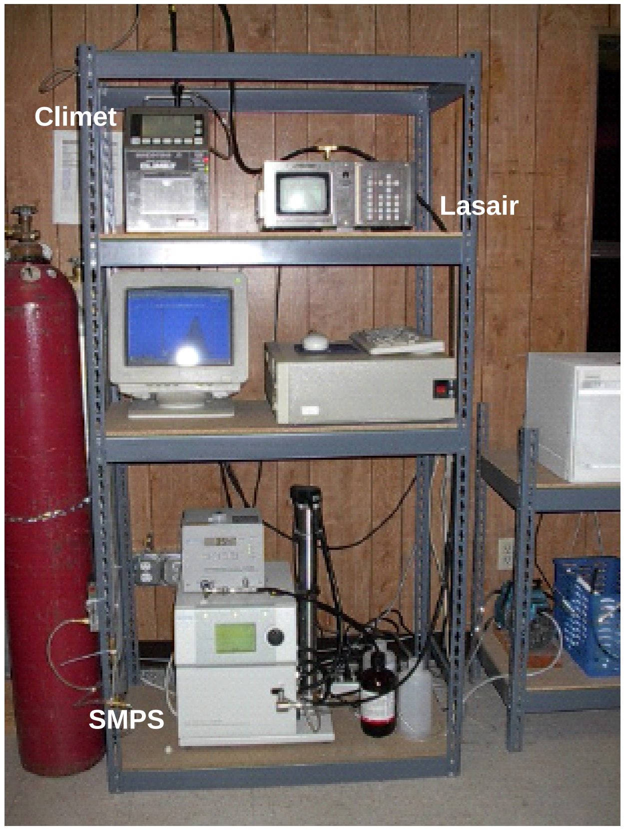

Figure 2-17. Climet, PMS Lasair, and TSI SMPS optical particle counter installations.

Figures 2-18 through 2-20 show the installation of continuous PM and gas-phase instruments in the Angiola Tower enclosures. There were four enclosures. Enclosures one, two, and three were at roughly 95 m agl, and enclosure four was at 50 m agl. Enclosures one and four each housed a nephelometer and a Climet OPC, which were operated as part of the Annual program. Enclosures two and three were used only during the winter measurement period. Enclosure two contained a 7-wavelength Aethalometer and a nitrate monitor. Enclosure three contained O_3 and NO/NO_y monitors.

A less strict interpretation of the guidelines was followed in the tower enclosures due to space limitations. However, the closer inlet spacing was not of concern because of the low flow rates of the instruments.


Figure 2-18. Angiola Tower enclosure for nephelometer and Climet OPC. Left shows Climet with partial view of the nephelometer. Right shows nephelometer with Climet removed.

Figure 2-19. Angiola Tower enclosure 2 showing nitrate monitor (left and top right) and Aethalometer installation.

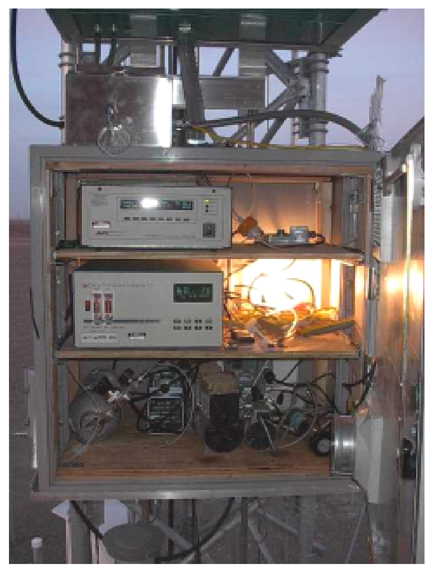

Figure 2-20. Angiola Tower enclosure 3 showing O_3 on top and NO/NO_y on the middle shelf.

Figures 2-21 to 2-28 illustrate typical installations of non-continuous PM samplers. The sequential filter sampler is the only sampler that ran on non-IOP days. All other samplers ran on a limited schedule that is shown in Tables 2-3 and 2-4. The Sequential Filter and Gas Samplers were installed to sample directly from the roof of the trailer. The other samplers, including the Canister, TENAX, PUF, DNPH, and MOUDI, sampled through lines that were not straight line drops from inlet to sampler. Instead these samplers were installed by the various measurement experts to have at most two 90° bends. These bends should not cause significant losses for the gas samplers and samplers with $PM_{2.5}$ inlets. The MOUDI, however, has size cuts from 0.1 to 15 µm in nine stages. The top three stages are above 3 µm and might suffer some losses in the inlet lines. In addition, the MOUDI inlets are uninsulated, so there may be changes in size due to temperature differences from outside to inside the shelters.

Figure 2-21. DRI MOUDI sampler installation.

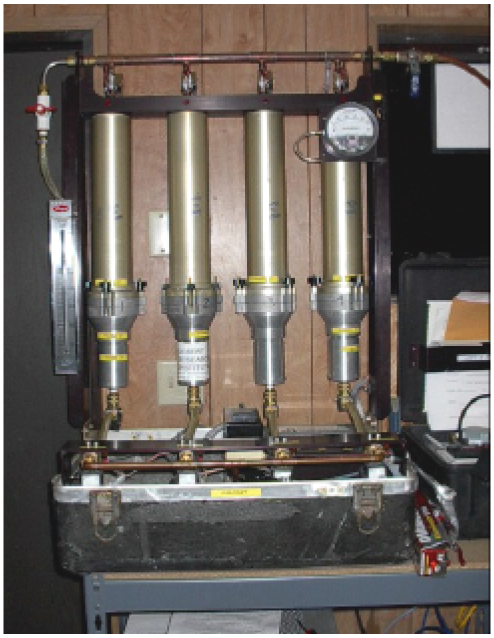

Figure 2-22. DRI PUF/XAD sampler installation.

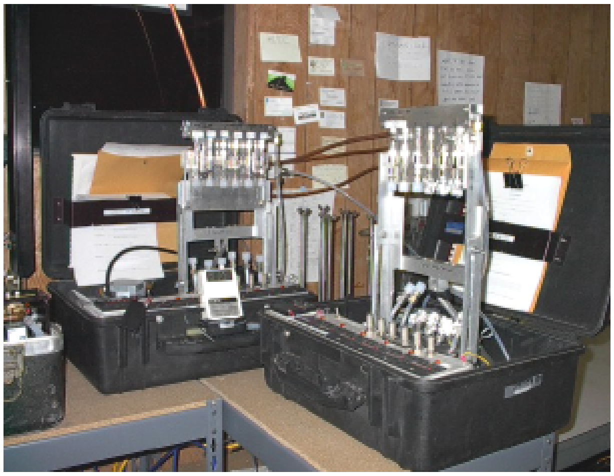

Figure 2-23. DRI TENAX sampler installation.

Figure 2-24. AtmAA DNPH aldehyde sampler.

Figure 2-25. OGI light hydrocarbon canister sampler. (From McDade, 2002)

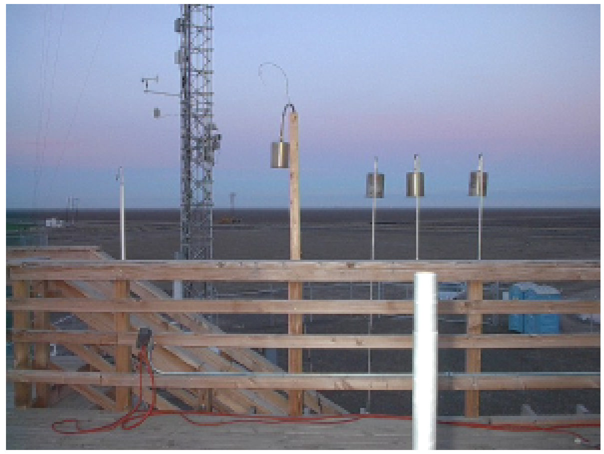

Figure 2-26. Downward-facing PUF/TENAX/Aldehyde inlet (on the left) and three MOUDI inlets (on the right).

Figure 2-27. DRI Sequential Filter Sampler.

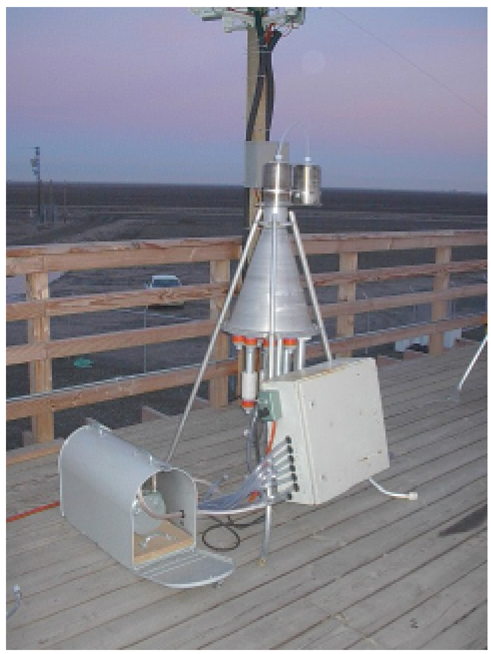

Figure 2-28. DRI Sequential Gas Sampler.

2.3 MEASUREMENT METHOD DESCRIPTIONS

This section presents brief discussions of those measurement methods listed in Table 1-2 that were used by STI. The Minivol samplers used for methods B, C, D, g, and h were operated by Technical and Business Systems, Inc. and are described in their field report (Technical and Business Systems, Inc., 2002). The discussions address the principles of operation and various operational issues unique to each type of sampler. More detailed information about the samplers operated by STI and their operation, calibration, and maintenance can be found in the SOPs in Appendix A. Calibration frequencies and techniques are summarized in Section 2.5.

The instruments used in CRPAQS ranged from commercial to research grade. We anticipated more operational problems with the research-grade instruments, as many of their operational procedures were newly developed for the study. Some of the research instruments were built for the study or had been built just prior to the study. In contrast, the commercialized instruments were off-the-shelf and had better-established operational procedures. In general, the research grade instruments did experience a greater number of operational problems. However, many of the commercial instruments also had operational issues as well.

2.3.1 Method A – Light Scattering Using the RR M903 Nephelometer

Light scattering was measured using the Radiance Research M903 Nephelometer at all CRPAQS sites. This is an Integrating Nephelometer which measures total visible-light scattering (i.e., forward-scatter through back-scatter) in an enclosed sampling volume once per second. It does not provide a direct measure of PM concentration, although light scattering is often well-correlated with $PM_{2.5}$ concentrations.

Unlike the other continuous and semi-continuous instruments, the nephelometers were operated outside but were installed in weather-proof enclosures. The enclosures were intended to reduce the amount of wind-blown large particles that entered the instrument and to keep insects out of the sampling chamber.

Ambient air was drawn through the enclosure using a fan. The instrument itself sampled from within the enclosure space through a fine mesh screen and a relative humidity (RH)-controlled heater designed to maintain the RH of the sampled air at or below 70%. The RH sensor was located at the inlet of the instrument at the beginning of the study but was relocated to the exhaust before the Winter Study (see discussion below). All nephelometers used in CRPAQS, with the exception of the two Angiola Tower instruments, used these enclosures and this sampling configuration. The enclosure is shown in Figure 2-12, and the nephelometer and its operation are described in detail in Appendix A-2.

Some of the issues associated with this instrument are summarized below.

<u>Configuration changes to improve RH control</u>

The sampling system was initially designed to sample at ambient temperature except when the RH was above 70% in which case an inlet heater warmed the air to reduce the RH to 70%. After several months of operation, it became clear that the heating (RH conditioning) system was not working as well as intended. Air that was heated to 70% RH by the inlet heater would cool down again by the time it reached the sampling chamber, resulting in the measurement being made at higher than 70% RH.

To alleviate this problem, at the start of the Winter IOP, the nephelometers were insulated, and a majority of the RH sensors were moved to the exhaust of the instruments to ensure that the RH was below 70%. For a few nephelometers, the RH sensors were not moved as planned until late in the IOP period. After the study, an intercomparison was performed with different configurations, and the effects on the data of the differing configurations were quantified. This investigation is described in Richards (2002), which is included in Appendix A-2.

Angiola Tower Installation

Nephelometers operated in the Angiola Tower enclosures were installed differently from those operated in the typical enclosures. The tower instruments were installed in the tower enclosures (see Fig. 2-18) and sampled ambient air directly through an inlet that extended out the top of the enclosure. The inlet tube was aluminum tubing with a 180° bend at the top to minimize water entrainment, and a screen to prevent insects and large particles from entering the instrument. The instrument exhausted through a tube to the outside of the enclosure drawn by fan.

Variability in RH control between systems

Although all nephelometers were set to regulate RH to 70%, there were variations of a few percent from the 70% target in some instruments. The actual RH values were recorded however.

2.3.2 Methods G-1, G-2 – $PM_{2.5}$ Black Carbon Using the Anderson Instruments AE1X and AE3X Aethalometers

Black carbon (BC) measurements were made using 1-wavelength (AE1X) and 7-wavelength (AE3X) Andersen Instruments Aethalometers. The Aethalometer measures light absorption by particles on a near real-time basis. The light absorption is related to the mass of BC because BC is the dominant optically absorbing material in the submicron size range.

The Aethalometer continuously collects an aerosol sample on a quartz-fiber filter and measures the attenuation of light transmitted through the filter and a supporting stainless steel mesh throughout a five-minute sample segment. The filter area and sample air flow rate are then used to calculate the ambient concentration of absorbing material.

The sample air flows through a 0.5 cm^2 area of the quartz-fiber filter tape. The instrument measures the transmitted light intensities through both the “sensing” portion of the filter (mentioned above) and an unexposed or “reference” portion of the filter. The reference measurement is made to correct for fluctuations in the intensity of the light source. When the filter tape sample spot reaches a maximum opacity, the instrument advances the tape and begins sampling at the next location.

The AE1X model measures light absorbtion at 880 nm. The AE3X model measures light absorption at 950 nm, 880 nm, 660 nm, 590 nm, 571 nm, 450 nm, and 350 nm. All absorption measurements by the AE3X model are referenced to the absorption of black carbon, so they should all read the same when the sample is purely black carbon. Differences between the channels are indicative of the presence of other light-absorbing species.

The Aethalometers were not sold with inlets, so inlet parts were purchased from other vendors. The inlet system included a Met One $PM_{2.5}$ sharp cut cyclone and aluminum refrigeration tubing. A coarse mesh screen was fitted into the rain hat of the cyclone to prevent insects from entering the instrument inlet. The Aethalometers were operated at a flow rate of 6.9 LPM so that the cyclone would have a cut point of 2.5 µm. This flow is higher than the 2 LPM normally used by the instrument and resulted in a higher frequency of tape advances than usual.

The Aethalometers and their operation are described in detail in Appendix A-3.

Some of the issues associated with this instrument are noted below.

Model differences

The two models differ in the design of the optical chamber and software. It is unclear whether the common 880 nm signal is identical due to these differences.

Tape advance issues

When the tape advanced, an extra record was sent to the data acquisition system (DAS). This extra record resulted in the DAS recording a factor of 2 error in the measurement for the time period before the advance. This error was corrected during data processing.

In the 7-wavelength Aethalometer, the tape advance initially took up to 20 minutes, and the tape would advance frequently because the ultraviolet channel would saturate rapidly. These two characteristics resulted in loss of a great deal of data due to down-time during tape advances. **A software change was made in the 7-wavelength systems during the Fall Study within a few weeks of their installation to reduce the tape-advance time to 10 minutes, which was the same as the 1-wavelength system. In addition, a tape-saver setting was employed to bypass the filter for 90% (instead of 50% which was standard) of each 5-minute sampling period, thereby extending the time between tape advances by a factor of 5. This setting was also applied for the 1-wavelength instruments at about the same time.**

Insect contamination

The majority of off-line times for both models of this instrument were due to removing small insects or portions of larger insects that were not effectively blocked by the inlet screen from the optical chamber of this instrument. Contamination by smaller insects posed a greater problem for the ANGI Aethalometer than for those at other sites.

Signal Oscillations

The 7-wavelength Aethalometer at Bethel Island was observed to have periodic signal oscillations on a few channels that were not reproduced on other channels. Occasionally, one or more channels on this instrument would not track the other channels. This may have been a problem with the data plots on the data logger because this behavior was not seen in the actual data.

There were also occasional erratic readings immediately after tape advances. The data for these periods were labeled as suspect.

2.3.3 Method H – $PM_{2.5}$ Organic and Elemental Carbon Using the R&P 5400

The continuous OC/EC measurement was made using the Rupprecht & Patashnick 5400 OC/EC. This instrument was newly commercialized and had not had prior field experience.

This instrument collects ambient $PM_{2.5}$ by impaction, oxidizes the sample by heating the impaction surface to high temperature in two temperature steps, and analyzes the carbon component of the PM as CO_2 using a non-dispersive infrared detector. Carbon evolved at the lower temperature is defined as “organic carbon”, while carbon evolved at the higher temperature is defined as “elemental carbon”. The collection process takes place for a full hour, and analysis of the collected PM occurs during the next hour. The instrument is built with two independent sampling and analysis systems. This configuration allows the instrument to continuously sample ambient PM on an hourly basis.

The inlet for the R&P OC/EC consists of a PM_{10} dichot head followed by a $PM_{2.5}$ sharp-cut cyclone.

This instrument was used as designed and installed as recommended by the instrument manufacturer. The OC/EC and its operation are described in detail in Appendix A-4.

Some of the issues associated with this instrument are described below.

<u>Bakersfield instrument location</u>

The Bakersfield OC/EC was installed at the ARB site, which was adjacent to the CRPAQS site in the same building. It was assumed that the spatial distance between this instrument and the rest of the BAC instruments would have no significant effect on data comparisons. Stainless steel tubing was used for the inlet instead of aluminum. It was assumed that the difference in inlet material would have no effect on the data collected by this instrument.

<u>Reliability of original instruments</u>

The first instruments installed at Angiola and Bakersfield were unreliable and were replaced with new instruments. The second instrument at Angiola began collecting valid data in late February 2000. It appeared to function reasonably well through mid April; however, flow checks were not performed during this period and the dwell temperature plateaus and durations were not set correctly, although they were considered reasonable. Data during this period were labeled as suspect. From mid-April through early November, there were numerous operational issues, set point and set point attainment problems, and other major interferences with the data. Data during that period were eventually invalidated. Thereafter, the instrument performed better.

At Bakersfield, there were numerous problems with the original ARB-owned instrument. It was later learned that the instrument was a prototype. It was finally replaced in early October

2000 and operated reasonably for the rest of the study. However, no useful data were obtained before October 2000.

Operation

The instruments purchased for CRPAQS were newly commercialized. Many operational issues were identified during the Annual Study, and modifications to the installation and operational procedures were made up until the fall period. These issues included excessive heating of the trailer due to the instrument, improper background CO_2 measurement, drifting response to CO_2-free air, and the overall unreliability of the first ANGI and BAC instruments. The heating issue was addressed by routing the furnace exhaust underneath the skirted trailer.

The instrument measures CO_2 relative to a background concentration in a carrier gas of filtered ambient air. Originally, the carrier gas was taken from inside the trailer, but the background concentration in the trailer was found to be variable from measurement to measurement. Although this was not a major problem, better consistency was obtained by moving this inlet from inside the trailer to near the gas-phase instrument inlets on the top of the trailer. This change also gave us a measure of outside CO_2 for each measurement cycle—in case that ever is of interest to someone.

At the beginning of the Winter Study, it became apparent that both instruments were exhibiting a drifting response to CO_2-free air. The drift was characterized on a monthly basis and was determined to be within acceptable limits.

The first two instruments had many design problems and were sent back to R&P after unsuccessful troubleshooting and inoperation for several months. The next instruments that were sent from R&P had fewer problems.

2.3.4 Method I-1 – Particle Sizing (0.3-10 µm) Using the Climet Instruments CI-500 Spectro.3

Sizing of particles between 0.3 µm and 10µm diameter was achieved using the Climet Instruments CI-500 optical particle counter (OPC). This instrument was selected by ADI after evaluation of several similar instruments. These evaluations are described in a paper and a memo included in Appendix A.5. The CI-500 is a modification of the standard Spectro.3 model. The modification was performed by Climet under guidance from ADI to increase the number of size channels from 8 to 16. While this is a commercially available instrument, it has not had prior field experience and is more typically used in a clean-room setting.

The OPC dilutes the sampled ambient air and passes the diluted particle stream across a laser beam. The OPC determines the size of a sampled particle by the quantity of light scattered by the particle and focused on to a photodetector using a system of mirrors. Because the amount of light scattered from a particle is a strong function of its size, precise and repeatable sizing of particles is possible. Particle concentrations in the counting chamber are kept low enough to ensure only one particle is measured at a time. The size indicated by an OPC depends on a particle’s refractive index in addition to its size. An appropriate optical calibration for use in the field is therefore required for accurate sizing of ambient particles.

The Climet was used alone in the ANGT tower installations and in parallel with the PMS Lasair OPC and the TSI SMPS in the ANGI trailer. In the trailer, the three instruments sampled from the same manifold which used a 10-µm cut dichotomous-sampler head as an inlet. A flow rate of 16.7 l/m was required to maintain the 10-µm cut point. The three instruments together drew significantly less flow, so a bypass pump and rotameter were added to draw and regulate the extra flow through the PM_{10} head. The tower instruments used a similar configuration. SOPs prepared by ADI for both configurations are included in Appendix A.5, along with a discussion of the rationale for selecting the Climet.

Some of the issues associated with this instrument are described below.

Calibration

The OPCs were calibrated in the field for sizing but not for number counting. The number counting calibrations were performed by ADI before and after the study at the ADI laboratory because of the need for an analytical laboratory for the calibration.

Operation

Although this instrument was not newly commercialized, its use in an ambient environment was uncommon and led to a number of operational issues. These issues include an unstable flow system and frequent contamination and laser problems.

The flow systems in the trailer and in each tower enclosure involved multiple pumps drawing air through the same inlet. Differences in pump ability and reliability led to inconsistencies in flow regulation and the need for more frequent operator intervention. In addition, the Climet flow calibration experienced excessive drift, such that the internal flow meter did not always reflect the correct flow as measured by an external standard.

The Climets were also found to be sensitive to vibration, which could cause the laser to become misaligned and occasionally dislodged. Contamination was also an issue. This instrument was sent back to Climet each time either of these problems was observed.

As a result of the reliability problems, the Angiola trailer particle-sizing instruments' size cuts were checked with a suspension of PSL on a weekly instead of monthly basis during the Winter IOP.

2.3.5 Method I-2 – Particle Sizing (0.1-2 µm) Using the PMS Lasair

Sizing of particles between 0.1 µm and 2 µm diameter was achieved using the Particle Measuring Systems (PMS) Lasair OPC. Like the Climet CI-500, this is a commercialized instrument that is typically used in a clean-room setting and not in the field.

This instrument operates on principles similar to the Climet CI-500 but is designed for the smaller size range. It sampled from the same manifold as the Climet. An instrument description and operational procedures are included in the particle-sizing SOP in Appendix A.5.

A memo prepared by ADI describing the reasons for selecting this instrument is also included in Appendix A.5.

Some of the issues associated with this instrument are described below.

Calibration

See Section 2.3.4, CI-500 calibration comment.

Operation

See Section 2.3.4, CI-500 transport flow-system comments. An additional issue involved frequent flow-rate inaccuracy as a result of a software glitch. The flow rate was controlled by software that required correct entry of temperature and absolute pressure (which is dependent on altitude). Frequent technician intervention was required to reset the software and then reprogram the instrument settings. The instrument was even sent back to PMS, but PMS was unable to resolve the issue. Periodic flow checks showed that the instrument's internal flow meter was usually reasonably accurate, although the sample flow rate was often high. For the Winter IOP, it was roughly 40% high. At the end of the study, however, the internal flow meter indicated that the sample flow was 40% high while an external measurement with a BIOS flow meter read 90% high. Because the data were consistent with those measured by the Climet instrument in the overlapping size bins, we reported concentrations calculated using the flow rates reported by the instrument, but flagged the data as suspect.

2.3.6 Method I-3 – Particle Sizing (.01-0.4 µm) Using the TSI SMPS

Sizing of particles between 0.01 µm and 0.4 µm was achieved using the TSI Scanning Mobility Particle Sizer (SMPS). Like the other particle-sizing instruments, this is a commercialized instrument that is typically used in a clean-room or laboratory setting and not in the field. This instrument and its operation are described in the SOP in Appendix A.5 prepared by ADI and are excerpted below.

The SMPS consists of a particle charger/neutralizer, a long Differential Mobility Analyzer (LDMA) and a condensation particle counter (CPC) in series. As the sampled aerosol passes through the radioactive charger (Kr-85), it acquires a known steady-state charge distribution. Within the LDMA the charged aerosol is pulled across a layer of clean air by an applied electric field while flowing down the length of the annular gap between two concentric tubes. Particles of different electric mobilities follow different paths, and the LDMA selects only that fraction of positively charged particles having electric mobilities within a narrow window. Most of the selected particles will have one positive charge with a relatively small fraction having two (or more) positive charges. The CPC then measures the concentration of the selected aerosol by condensing butanol vapor onto the particles and growing them to a size large enough to be detected and counted optically as they pass through a laser beam. Over a period of a few minutes the selection window of the LDMA is scanned from the minimum to the maximum selectable particle size in 53 increments. Theoretical relationships are used to convert from scan time to electric mobility to particle diameter. Knowledge of the charge distribution is used to convert measured concentrations of charged particles to total concentration for each particle size bin.

Some of the issues associated with this instrument are described below.

Calibration

See Section 2.3.4, CI-500 calibration comment. It should also be noted that the sizing technique used by the SMPS (differential mobility) is different from that used by the two laser systems. The PSL test spheres may be sized differently by the SMPS (mobility diameter) than by the PMS Lasair (aerodynamic diameter). In addition, the PSL spheres may have different mobility in the SMPS from ambient aerosol of the same size.

Operation

See Section 2.3.4, CI-500 transport flow-system comments. An additional issue involved the need for daily adjustment of the instrument flow meters. Although this requirement for daily electronic recalibration of the SMPS flow meters is somewhat excessive by field standards, it is considered to be typical practice (and acceptable) by those who use the instrument in a laboratory setting.

2.3.7 Methods J, K – $PM_{2.5}$/PM_{10} Mass Using the MO 1020 BAM

The $PM_{2.5}$ and PM_{10} mass measurements were made using the Met One Instruments Beta Attenuation Monitor (BAM) model Met One 1020. This commercially available instrument had not had much field experience.

Separate instruments were required for the $PM_{2.5}$ and PM_{10} mass measurements. The $PM_{2.5}$ instrument uses a PM_{10} dichot head followed by a $PM_{2.5}$ sharp cut cyclone. The PM_{10} instrument has only a standard PM_{10} dichot head.

The BAM collects particles by pulling a measured volume of ambient air through a 1 cm^2 circular spot on a glass fiber filter tape. A Beta detector counts the number of Beta particles passing through the filter tape before and after the filter collects particulate matter. A stable source of Beta particles ensures repeatable measurement characteristics. The difference between the before and after measurements is the attenuation of beta energy due to the collected aerosol. Mass is calculated from the ratio of the attenuation due to the aerosol sample to the attenuation from a standard calibration membrane.

The instrument samples particles for 50 minutes of each hour. After 50 minutes, it measures the beta energy transmitted through the spot on the tape. After the measurement is completed, the instrument advances the tape and commences sampling at the next location.

The BAM was modified slightly for CRPAQS. The standard instrument comes with a calibration membrane that is calibrated for 1000 $\mu g/m^3$. Because concentrations of this magnitude were not anticipated at any of the CRPAQS sites, Met One provided a different membrane that was calibrated for approximately 200 $\mu g/m^3$. This was the only modification made to this instrument.

Some of the issues associated with the BAM are described below.

Inlets

At sites with both $PM_{2.5}$ and PM_{10}, instruments, the inlet length of the two instruments differed by the length of the $PM_{2.5}$ inlet adaptor (<1 ft). It was assumed that this difference in inlet length did not bias the accuracy of either measurement.

Nozzle leaks

During high relative humidity (RH) conditions, the BAMs had a tendency to develop leaks around the nozzle. The nozzle is pressed tightly against the filter tape during sampling and then raised as the filter is advanced. During moist conditions, pieces of tape would occasionally stick to the nozzle when it was raised. These tape fragments would prevent the nozzle from properly seating during collection of the next sample. During normal conditions, the seal was tight and the flow rate would drop from 16.7 l/m to less than 0.5 l/m when the inlet was blocked during calibrations. The leaks were discovered during a calibration when the flow rate stayed high when the inlet was blocked. Further exploration revealed the problem. To alleviate the problem, the nozzles were cleaned frequently during and after high RH conditions, and the flow rates were checked.

No sample RH control

The BAM does not control RH. Because of differences in indoor and outdoor temperatures, the RH in the instrument at the time of the mass determination may differ from the outdoor RH. The aerosol mass can change from outdoors to indoors depending on water absorption or desorption due to the change in RH. Under most circumstances, the measured mass concentration will be equal to or less than the ambient aerosol mass concentration.

Initial flow control problems at SJ4

At installation, the SJ4 BAM was set up by the Bay Area Air Quality Management District (BAAQMD) without a temperature and pressure sensor and operated in standard flow mode. On June 23, 2000, temperature and pressure sensors were installed, but software problems prevented the instrument from recognizing the sensors. The software problem resulted in the flow controller assuming the temperature was 50°C. On July 13, a flow check revealed that the flow rate was 13% lower than indicated by the BAM, probably due to the incorrect temperature. On July 17, a software patch was installed. The flow meter was calibrated on July 18 and subsequently appeared to work properly. BAM mass data from June 23 through July 17 were labeled as suspect.

2.3.8 Methods L, M – $PM_{2.5}$ Mass & Elements, Ions, and Carbon Using the DRI SFS

Samples of $PM_{2.5}$ mass, elements, ions, and carbon were collected using a sequential filter sampler (SFS) designed and built by DRI, and analyzed at the DRI laboratories. The SFS draws air through a size-selective inlet and through a selected set of filter packs. The sampler used in CRPAQS had 16 channels which allowed two simultaneous samples to be collected at up to 8 different pre-defined multi-hour time periods. Solenoid valves controlled by a timer were set to switch among seven sets of pre-mounted filter packs at preset intervals. One set of filter packs was reserved as a blank. For each sample period, one filter pack, which contained a Teflon filter with a citric acid-impregnated cellulose backup filter (method ID "L"), was analyzed for mass, elements, and ammonia. A second filter pack which contained a quartz filter with a NaCl-impregnated cellulose backup filter, was analyzed for ions and carbon (method ID "M"). All of the filter packs were preceded by an aluminum nitric acid denuder on the inlet. One set of 24-hr filters per day was collected during the Annual Study, and five sets of filters per day were collected on Winter IOP days on the schedule shown in Table 2-3.

The inlet of the sampler has a Bendix 240 cyclone with a cut point of 2.5 µm when operated at a flow rate of 113 lpm. Each filter pack has air drawn through it at 20 lpm. A make-up flow rate of 93 lpm is drawn through a separate port to provide the 113 lpm flow rate required by the inlet.

These samplers have been used widely in previous field projects and were used as designed. An SOP for these samplers is included in Appendix A.13. That SOP was developed for a previous project and does not exactly reflect the configuration used in CRPAQS, but the operational procedures are still appropriate.

The only operational issue associated with this sampler was a misunderstanding about whether the technicians were supposed to adjust the makeup flow rate periodically. It was decided that the flows were preset by DRI for the type of operation being performed, and they would be left alone. After the January 2000 audits, these procedures were made clear and makeup flow was routinely checked but not adjusted.

2.3.9 Method O – NO_y Using the TEI 42C/Y

The NO_y measurement was made using the Thermo Environmental 42C/Y instrument. This instrument measures NO by detecting light emitted from a chemiluminescent reaction between NO and ozone. NO_y is measured by reducing NO_2 and nitrate-containing species in the sample to NO in a molybdenum catalytic converter and then measuring the resultant NO.

This instrument is a modification of the high sensitivity TEI 42C NO/NO_x instrument, with its NO_y-to-NO converter removed from the body of the instrument and placed outside at the sampling inlet so that the more reactive species, including HNO_3 and PAN, can be immediately converted to the more stable NO species. It was used as provided, however the on-site calibration system was mated to its sampling inlet. This is a non-certified commercial instrument that has had much less field use than the standard instrument. An SOP prepared by CE-CERT for this instrument is included in Appendix A.7

Some of the issues associated with this instrument are summarized below.

Calibration gas injection

The physical connection between the calibration system and instrument inlets varied between sites. At Bethel Island and Sierra Nevada Foothills, calibration gas was delivered to the instrument inlet through a 1/4" Teflon tube that was fed into the instrument inlet. At Angiola, Angiola Tower, and Bakersfield, calibration gas was delivered to the instrument inlet through a 1/4" Teflon "T" immediately downstream of the inlet, keeping the inlet free of obstructions. It is assumed that this difference in installation had no effect on the measurements made at any of the sites.

Calibration for NH_3 and HNO_3

The instrument response to NH_3 was not quantified at any of the CRPAQS sites using the transfer standard. At a majority of the sites, the response to NH_3 was quantified using the site calibrator. The ANGT instrument response to NH_3 was never quantified. The NO_y instrument is not supposed to be able to measure NH_3; therefore, we assume that this will not affect the measurements.

Prior to the Winter Study, an assessment of the instrument response to HNO_3 was unsuccessfully attempted. This instrument should be able to measure HNO_3, but because of the reactivity of HNO_3, it might be inefficient at this measurement. Because of the failure of this check, it was discontinued by the start of the Winter Study. For data processing purposes, we assumed that the instrument measured HNO_3 and other nitrogenous species as accurately as it measured NO and NO_2.

Operational issues

This instrument is not newly commercialized, but the instrument vendor does not consider it to be certifiable. A number of operational issues arose during the study, including filter fouling, optical window fouling, and sensitivity to pressure fluctuations

The NO channel on some instruments occasionally showed reduced response to NO. This problem was normally associated with NO filter fouling or an accumulation of particles in the capillaries. NO filter fouling occurred at many winter sites as a result of high PM loading, and led to an increase in frequency of filter changes. The accumulation of particles in the capillaries occurred most frequently at ANGI and was addressed as needed.

The fouling of the optical window is an issue relevant to all NO_y instruments that are operated over a long time period, including the ANGI and BAC instruments. Fouling was identified by a gradual decline in instrument response and led to cleaning of the optical window midway through the Annual Study. This action led to instrument instability for several weeks. As a result, when instrument response decreased again, no action was taken except to characterize the system.

Finally, the ANGT NO_y instrument was found to be sensitive to changes in the incoming gas temperature and pressure. This was considered to be an issue only during calibrations, when dramatic changes in gas property occurred because the calibration gases were at different conditions than the ambient air. This sensitivity resulted in the instrument taking a long time to stabilize.

2.3.10 Method P – O_3 Using the API 400A

O_3 was measured using the Advanced Pollution Instruments (API) 400A UV absorption ozone monitor. This is a certified commercial instrument and is used at many ARB air quality monitoring sites.

The detection of ozone molecules is based on absorption of 254 nm UV light due to an internal electronic resonance of the O_3 molecule. The Model 400A uses a mercury lamp that emits a large majority of its light at 254 nm. Light from the lamp shines down a hollow quartz tube that is alternately filled with sample gas, then filled with gas scrubbed of ozone. The ratio of the intensity of light passing through the scrubbed gas to that of the sample is used to calculate the ratio I/I_0. This ratio and the temperature and pressure are used to calculate the ozone concentration (Beer's Law). The effects of temperature and pressure are addressed by directly measuring them and including their actual values in the calculation.

The instrument and its operation are further described in the SOP in Appendix A.8.

Some of the issues associated with this instrument are described below.

Operational issues

This is a commercial instrument with many years of field experience. These instruments experienced valve failures and unusual sensitivity to the incoming gas properties. The ANGI and ANGT instruments experienced frequent failures of the switching solenoid valve. This issue was easily diagnosed and was addressed by replacing the valve.

The SNFH instrument was found to be sensitive to changes in the incoming gas temperature and pressure. As with the NO_y monitor, this was considered to be an issue only during calibrations when sudden changes in gas property occurred. The solution was to allow a longer time for stabilization.

2.3.11 Method Q – $PM_{2.5}$ Nitrate Using the R&P 8400N

The nitrate measurement was made using a Rupprecht & Patashnick model 8400N. This is a non-certified, recently commercialized instrument that had primarily been used only by its developer prior to the study. The design of this instrument is based on ADI's laboratory instrument. It was used as provided by R&P and as set up by ADI with no modifications other than software upgrades to the latest configuration.

This instrument uses flash vaporization to convert particle nitrate to nitrogen oxides and measures the resulting gases with a chemiluminescent NO detector. The line between the outside inlet and the instrument was insulated to minimize changes in the particle nitrate concentration due to condensation or vaporization caused by temperature changes. The ambient sample is pulled through a cyclone inside the instrument to remove particles above 2.5 µm and through a carbon honeycomb denuder to remove potential gaseous interferences.

The sample is humidified to increase collection efficiency, drawn through a jet at sonic velocity, and impacted on a nichrome flash strip for 285 seconds. (This sample time is shorter than that described in the SOP for this instrument in order to achieve a five-minute sample time.) After collection, the collection cell is flushed with nitrogen, and the impacted sample is flash-heated. The nitrogen oxides that evolve during the flash are carried by the nitrogen through a molybdenum converter, which converts the nitrogen oxides to NO. The resulting NO is measured using a standard chemiluminescence NO monitor. The NO response before, during, and after the flash is recorded, and the area under the curve is considered to be proportional to the mass of nitrate in the sample. Approximately 85% theoretical conversion is assumed. The instrument and its operation are described in more detail in Appendix A.9.

Some of the issues associated with this instrument are described below.

Software

This instrument was newly commercialized, and revisions to the instrument software were constantly underway. The software was updated on the CRPAQS nitrate instruments at least twice and, for some instruments, three times. These changes were taken into account in the data processing.

Inlets

The inlets for the WAG and WGT nitrate instruments were specially modified by R&P to have a side inlet. This design was needed to accommodate installation in the enclosures used at WAG. It was assumed that this difference in installation did not affect the measurements made by either instrument, because both instruments sample $PM_{2.5}$ nitrate and because both nitrate measurements at WAG were made using the same modified inlet design.

Pump placement

The placement of the pumps and calibration cylinders varied at each site. It was not until the middle of the Winter IOP that it became clear that this might have an effect on the measurements. The pumps turned out to be sensitive to temperature and pressure, and operated better at low temperature. For pumps that were outside in the elements, the vacuum in the NO instrument was found to vary slightly diurnally and also with wind gusts. Regulators on gas cylinders that were placed outside were found to stick occasionally. These problems caused the NO instrument reaction cell vacuum (Rcell) to vary and changed the calibration of the NO monitor. This pressure was measured and the effects were accounted for in data processing. The pump problem was alleviated somewhat by enclosing the pumps, but they still experienced diurnal variations in efficiency.

Availability

This instrument was newly commercialized and was not yet available for measurements during the fall at BAC and ANGI as originally planned. All of the nitrate monitors became available at the beginning of the Winter Study, but even then, not all instruments operated properly. Due to time constraints, the instruments were not thoroughly acceptance tested, and several instruments had to be returned to R&P for repairs.

Operation

Operational issues during the Winter Study included procedural changes, instrument failures, inlet disconnects, and an unexpected sensitivity to specific parameters.

Although an SOP was developed for this instrument prior to the study, some details were not clear and were only added to the operational procedures after an external audit in November 2000, including the need to check the sample flow rate biweekly and regulate it within the preferred range.

The instruments experienced several component failures during operation, including repeated battery terminal corrosion at SNFH and temperature sensor shorting at all sites. Both types of failures led to the inoperability of the instrument for periods of time. The temperature sensor problem was due to a design flaw that allowed the sensor to become wet and short out. When the sensor feature was deactivated, the instrument resumed normal operation. The reason for the battery corrosion was never identified. At first, the corrosion was removed. Eventually the battery and terminals had to be replaced before the instrument would operate again.

During a few troubleshooting episodes and external audits at Corcoran (and maybe elsewhere), the tube between the internal cyclone and the denuder was disconnected and not reconnected immediately. This resulted in sampling air from inside the shelter. These times were noted in the logbooks, and the instrument was flagged as being off-line.

Because the nitrate instruments were newly developed and did not have sufficient acceptance testing, the importance of some operational parameters was not realized until the instruments had been operated for several months. For example, the instrument calibrations required a constant cell vacuum (Rcell), but it proved to be difficult to maintain a stable Rcell value. As noted above, after several weeks of troubleshooting, the instrument pumps were enclosed. This helped alleviate the problem.

In addition, the occurrence of flash strip dents and misplacement became clear during the study. Flash strips became pocked at the point of impingement and sometimes twisted after some use. They also broke frequently. After observing that flash-strip impairment sometimes occurred without breakage, the pocked or twisted strips were replaced whenever they were found.

2.3.12 Method R – HNO_3 Using the TEI Dual Converter 42C/Y

The HNO_3 measurement was made using a modification of the Thermo Environmental 42C/Y NO/NO_y instrument. Like the NO_y instrument, this instrument uses a chemiluminescence NO monitor to measure NO_y and HNO_3. The modified instrument uses a dual converter configuration, with two parallel converters placed at the inlet. Both converters are identical to the one used for the NO_y instrument, but an NaCl-coated denuder filter is placed upstream of the second converter to scrub HNO_3 from the sampled ambient air. Like the NO_y design, both converters are placed outside at the inlet and not in the instrument body, allowing more reactive species to be measured. HNO_3 is measured as the difference between the measurements with and without the nylon scrubber. This assumes that the scrubber does not remove any other oxidized nitrogen compounds.

This instrument was used as provided by TEI; however the on-site calibration system was mated up to its sampling inlet. This is a non-certified commercial instrument that has only been used in a research rather than operational context.

The same SOP used for the NO/NO_y monitor was used for this instrument. It is included in Appendix A.7. The calibration protocol was also the same.

This instrument was only used at ANGI and SNFH and only operated during the winter. The operational issues associated with this instrument include those for the NO_y monitor. These instruments also suffered from a few problems of their own and a major uncertainty in the zero value which we believe renders the HNO_3 data unusable. These problems are described below.

Zero uncertainty

The expected concentrations of nitric acid at these sites in the winter were only on the order of 1 ppb. Because the instrument needs to measure a 1 ppb difference in NO_y signals that are typically 10-50 ppb, we expected that it would be difficult to get a clearly detectable signal in the winter. Because the instrument response close to zero was so important, automatic matrix zeros were performed daily at 0600, 1100, 1600, and 2100 PST, and two-point calibrations using zero air, NPT, NO, and NO_2 were done at 0200 PST.

After the field program, analysis of the matrix and zero-air zeros showed that the zeros of the NO_y channels behaved as expected, but the NO_y minus HNO_3 zeros often gave positive signals up to 2 or 3 ppb. There were also several periods when the NO_y minus HNO_3 signal was larger than the NO_y signal, even accounting for the difference in zeros. The converter efficiencies were consistently measured at 100%. We were not able to positively associate the apparent contamination with any specific parameter, although a majority of the problems seemed to occur in early to mid morning. One hypothesis is that there might have been a problem with degassing from the denuder.

From these results, it was determined that the uncertainties in the zeros were such that it was impossible to obtain useful HNO_3 measurements for the Winter Study from these two instruments. Therefore, all of the continuous HNO_3 data were invalidated.

Operation

The main operational issue associated with this instrument was intermittent out-of-bounds converter temperatures. The converter temperature readings for both the ANGI and SNFH instruments exceeded 1000°C on occasion. These events were accompanied by blown fuses. Because the instruments were still able to measure NO_2 after these events, the high readings were assumed to be the result of the blown fuse and an electronic glitch rather than actual high temperatures in the converters. Concerns about converter degradation can be addressed by investigating the nightly calibrations of this instrument.

2.3.13 Method T – $PM_{2.5}$ Sulfate Using the R&P 8400S

The sulfate measurement was made using the Rupprecht & Patashnick Model 8400S. This is a non-certified, recently commercialized instrument that had primarily been used only by its developer prior to the study. The design of this instrument is based on ADI's laboratory instrument. It was used as provided by R&P and as set up by ADI with no modifications.

The instrument operates in a fashion similar to that of the Rupprecht & Patashnick nitrate instrument described in Section 2.3.11 with a few exceptions: (1) the flash strip is made of platinum, (2) air is used as the carrier/purging gas, and (3) the SO_2 resulting from the flash volatilization of the sulfate in the ambient sample is measured using a UV pulsed-fluorescence SO_2 monitor. The conversion of sulfate to SO_2 was measured at approximately 30% for sulfate standards, but this rate may vary for ambient aerosol depending on the composition. The instrument and its operation are described in the SOP in Appendix A.10.

Some of the issues associated with this instrument are summarized below.

Availability

This instrument was even newer than the nitrate to the commercialization process. These instruments did not become available until the last few weeks of the Winter Study, and even then, the ANGI instrument failed repeatedly.

Operation

See Section 2.3.11, R&P 8400N nitrate instrument flash strip impression comments.

2.3.14 Method U – Light Hydrocarbons Using the OGI Canister Sampler

Samples of light hydrocarbons (up to undecane) were collected using a canister sampler designed and built by OGI and analyzed at the OGI laboratories.

The sampler had four channels which enabled a single sample to be collected at four different pre-defined time periods. A timer and solenoid valves were used to cycle flow between the different channels. This allowed four multi-hour light-hydrocarbon samples to be collected on each IOP day. The sampling schedule is shown in Table 2-3. These samplers have had widespread field use and were used as designed. An SOP for the sampler is included in Appendix A.14.

2.3.15 Method V – Heavy Hydrocarbons Using the DRI TENAX Sampler

Samples of heavy hydrocarbons were collected using TENAX samplers designed and built by DRI, and samples were analyzed at the DRI laboratories. These samplers were designed to draw air through TENAX cartridges for a preset time period. Each sampler was capable of collecting six samples. The samplers were set up to collect two samples in parallel for each sampling period in order to provide a backup or redundant sample.

Four multi-hour samples per day were collected during the Winter IOP days at the BTI, ANGI, and SNFH sites. Because parallel samples were collected, each sampler was able to collect only three samples per day, so two samplers were used at each site to cover a full day of IOP sampling.

The second sampler at each site was originally designed for a different purpose and was modified to accommodate TENAX samples. This modification led to breaking of the substrates. This problem was resolved by working with DRI to improve the sampler design. These same samplers also had a programming problem that affected the start time. Before resolution of both problems, the samplers were manually started. These problems were resolved by the beginning of the second episode.

The TENAX samplers have had widespread field use and were used as designed, except for the problems with the second samplers noted above. The sampling schedule is shown in Table 2-3, and the design and operation of the samplers are described in the SOP in Appendix A.15. The TENAX heavy-hydrocarbon data will be reported by Barbara Zeilinska at DRI.

2.3.16 Method W – $PM_{2.5}$ Organic Compounds Using the DRI Teflon-Coated Glass Fiber/PUF/XAD Sampler

Samples of $PM_{2.5}$ organic compounds were collected using a Teflon-coated glass fiber/PUF/XAD sampler designed and built by DRI, and analyzed at the DRI laboratories. The data will be reported by Barbara Zeilinska of DRI. These samplers have had widespread field experience and were used as designed.

The sampler had four channels which allowed samples to be collected for up to four different pre-defined multi-hour time periods. The sample is collected by pulling ambient air through a Teflon-coated glass fiber filter followed by a cartridge that contained a PUF/XAD/PUF sequence of media. The sampler was preceded by a 2.5-µm cut cyclone and operated at 113 l/m. A timer and solenoid was used to cycle power between the different channels. Two multi-hour samples per day (1600-0500 and 0500-1600) were collected on IOP days. Additional information is included in the SOP in Appendix A.16.

Some of the issues associated with this sampler are described below.

Operation

The primary operational issue involved a problem with the construction of one of the PUF/XAD cartridges. Improper insertion of the downstream PUF plug allowed liquid XAD to be sucked past the PUF into the vacuum system of the sampler. This issue was resolved by working with DRI to improve the cartridge preparation procedures. The sample that was contaminated was flagged for invalidation. This problem was resolved by the beginning of the second episode.

2.3.17 Method X – Aldehydes Using the AtmAA DNPH Sampler

Samples of aldehydes were collected using a sampler designed and built by AtmAA and analyzed at the AtmAA laboratories. These samplers have widespread field experience and were used as designed.

Each sampler had six channels of which four were used for sampling. The sampler was preset to collect samples for four multi-hour time periods. The sampler was used only during the Winter IOP, and four samples per day were collected on IOP days at the times shown in Table 2-3. A "SprinklerThinker" timer and solenoids were used to cycle flow between the different channels. The spare channels were used to collect blanks and duplicates on a prescheduled basis, with a blank collected on one IOP and a duplicate collected on another; about 10% of the samples were blanks or duplicates. Each sample was drawn through a KI-coated copper tube (to scrub ozone) and a filter before being routed through the DNPH cartridge being used for the sample. The sample cartridges used a C-18 substrate. The cartridges were contained in a sampler unit. The flow controller, pump, and timer were in a separate box connected downstream of the sampler box. The sampler and its operation are described in Appendix A-17.

The only operational issue with the system was the way the timers were initially set. There was a problem presetting the timers to go off on the next day. This problem was alleviated by reconfiguring the timers before the second IOP.

2.3.18 Method Y – SO_2 Using the TEI 43S

The SO_2 measurement was made only during the Winter Study using the Thermo Environmental Instruments 43S SO_2 monitor. This is a certified commercial instrument that has had considerable field experience. This instrument uses the principles of UV-pulsed fluorescence to measure SO_2. The actual monitor used in CRPAQS was an older instrument with analog output. This differentiated it from other instruments used at the CRPAQS Anchor sites, which had both analog and digital output. The instrument and its operation are described in Appendix A-11.

Some of the issues associated with this instrument are noted below.

Model or settings

During installation, it became clear that the instrument display did not identically match the analog input to the data system. The difference between the two was unable to be characterized but was on the order of 0.5 ppb. The analog input was used as the basis for calibration, so the difference was immaterial.

Calibration

The response of the instrument to span gas sent directly to the instrument as opposed to through the entire inlet was slightly different. Because no leaks were identified, it was assumed that this difference was the result of conditioning of the inlet tube. The instrument response to calibration gas sent to the ambient-air inlet was checked nightly. At installation and decommissioning, multipoint calibrations were performed through the back of the instrument.

2.3.19 Method b – PAN/NO_2 Using the CE-CERT Instrument

The PAN/NO_2 instruments were built by CE-CERT for CRPAQS. They were operated at one site during the Fall Study and four sites in the Winter Study. The instrument continuously pulls ambient air through a sample loop. Once per minute, it shunts the air in the sample loop through a chromatographic column using zero air as a carrier gas. The NO_2 and PAN in the sample are adsorbed by the column and then slowly eluted. The eluent is analyzed by a luminol detector in which the luminol reacts with the NO_2 and PAN in the sample, generating light that is detected by a photomultiplier. The NO_2 in the sample elutes from the column a few seconds before the PAN does, so the signals can be distinguished from each other. In essence, the instrument takes an instantaneous sample once per minute and then takes a minute to analyze the sample.

This instrument was still in the design stages during CRPAQS, although many of the issues associated with its component parts were resolved during the CRPAQS field study. Most modifications to the instrument design were made during the Winter Study.

The PAN/NO_2 instrument shared a sampling inlet and calibration line with the NO channel of the NO_y monitor; both instruments sampled from the same manifold in the shelter. Because the NO_y instrument sampled ambient air at four times the rate of the PAN/NO_2 instrument, the mating of these two instruments to the same manifold reduced the delay time for ambient air to arrive at the PAN/NO_2 instrument.

The design and operation of the PAN/NO_2 instrument is described in Appendix A.12.

Some of the issues associated with this instrument are described below.

Inlets

Because the PAN/NO_2 sampled from the same inlet as the NO/NO_y instrument, whenever the NO_y instrument was off-line, the PAN/NO_2 instrument was also off-line. This was not considered to be a problem because the measurements of this instrument are interpreted using the NO_y measurements.

Calibration and data processing

The instrument was calibrated nightly using the station calibrator at the same time as the NO_y instrument calibration. In addition, it performed its own internal zero and span calibrations every two hours to detect calibration drift. The instrument's internal calibration system was found to be unreliable over the course of the Winter Study. As a result, the nightly calibrations using the on-site calibrator as well as comparisons with the NO_y monitor data were used instead to process the data.

In addition, CE-CERT staff were uncomfortable with the ability of the instrument to measure PAN in the first place. No automatic data processing procedures had been developed for this instrument for the CRPAQS study. The PAN data from all of the PAN/NO_2 instruments were very difficult to process properly and required a great deal of manual analysis and manipulation. For this reason, the data were processed only for two Winter IOP periods (December 26-28, 2000, and January 4-7, 2001).

Operational problems

Other operational issues included erratic response to calibration gas, expired luminol supply, and failing sample pumps. The response of this instrument to calibration gas was variable. As a result, instrument response was determined only through comparison with the NO_y instrument response. Problems with the luminol supply and the sample pumps were experienced at ANGI, BAC, and SNFH. The failure of the luminol supply was erratic and required replacement of the solution. Although the luminol was replaced by its expiration date, the instrument response, characterized using the NO_y instrument response, decreased dramatically before the expiration dates. The sample pumps had a lifetime of one month, and their failure was addressed by pump replacement.

2.3.20 Methods c, d – Ion/Carbon Size Distribution Using DRI MOUDI Sampler

The MOUDI is a Micro-Orifice Uniform Deposit Impactor for the collection of size-segregated suspended particulate matter. Size-resolved particulate ion and carbon samples were collected using commercial MOUDI samplers with different substrates operated in parallel. One to two multi-hour sample sets per day were collected during Winter IOP days on the schedule shown in Tables 2-3 and 2-4. Only two samples per day could be collected because of the limited number of MOUDIs available and the long time required to change substrates on the samplers. The samples were analyzed at the DRI laboratories.

The MOUDI is an eight-stage cascade impactor in which air is drawn through a series of micro-orifice nozzles; and particles with different aerodynamic diameters are collected onto a series of impaction plates. The 50% cut points are 0.105, 0.148, 0.37, 0.54, 1.0, 1.8, 3.2, 5.6, and 15 μm. Teflon impaction substrates (method ID "c") were used for collection of samples for ion analysis using ion chromatography and automated colorimetry. Aluminum impaction substrates (method ID “d”) were used to collect carbon samples for thermal optical reflectance analysis. The design and operation of the sampler are described in the SOP in Appendix A.18.

There were no major field problems with this sampler.

2.3.21 Methods i, j – Denuder-difference HNO_3 and NH_3 Using DRI SGS Samplers

HNO_3 (method ID “i”) and NH_3 (method ID “j”) were measured using two different DRI Sequential Gas Samplers (SGS). Each sampler was capable of collecting six pairs of simultaneous filter samples. One filter of each pair was preceded by a denuder for either HNO_3 or NH_3, and the concentrations of HNO_3 and NH_3 were calculated as the differences of the nitrate and ammonium concentrations, respectively, between the filter pairs. Timer-operated solenoids allowed up to six multi-hour samples to be taken before servicing the sampler. The samplers were operated only on Winter IOP days, and five samples per day were collected on the schedule shown in Table 2-3.

The HNO_3 sampler used anodized aluminum denuders and NaCl-impregnated cellulose filters. The denuders sampled directly from the ambient air with no inlets or cut devices and with the filters attached to the backs of the denuders. The non-denuded HNO_3 filters were also exposed face-down, but open-faced to the ambient air. The filters were analyzed by ion chromatography.

The NH_3 sampler had a Teflon-coated Bendix 240 cyclone upstream of a plenum in which all the filters were mounted. The cyclone removed particles greater than 2.5 µm. The NH_3 sampler used citric acid-coated annular denuders and citric-acid impregnated cellulose filters. The denuders consisted of 16 hydrogen-fluoride-etched glass tubes. The filters were analyzed by automated colorimetry.

These samplers have been used by DRI in numerous field projects. The samplers and their operation are described in detail in the SOP in Appendix A.19. This SOP was taken directly without modification from a prior project.

The samplers generally worked well, although initially there was a contamination problem on one sample at SNFH. It was determined that loading procedures needed to be cleaner. All debris entrained into the sampler was removed, and the samples that were contaminated with debris were flagged for invalidation. This problem was resolved by the beginning of the second episode.

2.4 DATA ACQUISITION SYSTEMS

During the design of the CRPAQS Anchor-site measurement plan, it became clear that the data acquisition systems (DAS) used had to be very versatile, robust, and powerful. The new generation of monitoring instruments used in CRPAQS typically put out serial data rather than analog signals, and each instrument used a different format and put out different parameters on differing schedules. The serial data from the instruments contained not only concentration data, but also numerous operational parameters for the instruments. The data systems needed to be able to record these serial data as well as analog signals from older instruments. In addition, the DAS needed to control the automatic calibrators at the sites and to send data back to the STI data center for daily review, display on the Web, and archiving. We were unable to find a commercial system that met all the requirements, so a new PC-based system was developed for CRPAQS. The design and operation of the DAS are described in this section and the parameters recorded from the continuous instruments are listed.

2.4.1 DAS Design and Operation

The DAS was designed to acquire both serial and analog data on varying schedules, record on-site all data from all serial and analog instruments, generate files of one-minute concentration data, automatically send daily files to STI over the Internet or by telephone modem, store all files on-site for later retrieval, be accessible by modem to transfer files that did not go through to STI automatically, and control various calibration functions both automatically and manually.

The system was designed to be scalable for as many instruments as we might require at any site and included a scripting language to control instruments and other external devices for special functions, such as periodic calibrations and diagnostics. It was also able to automatically parse the serial data received from each instrument to extract the concentrations of interest and include them in a data file that was transmitted to STI daily. The DAS automatically reboots after power interruptions and does not lose data recorded before the power fails. It can be accessed and reconfigured remotely.

The DAS has an on-site display that provides the current data from each instrument in tabular form and also displays up to three time-series graphs of up to eight parameters each. The graphs have a zoom feature to explore short or long time periods and to display selectable concentration scales.

The systems were configured differently for each site. A separate initialization (.ini) file was developed for each site. The .ini files defined how the DAS dealt with the signals from each instrument and programmed the calibrations. A separate section is included in the .ini file for each instrument, calibrator, and digital input or output. The .ini file also programmed the DAS to run script files at preset times to carry out instrument calibrations and other diagnostic tests.

Over the duration of the field study, changes were made to the DAS software to fix bugs and improve the program. The versions of the software and the .ini files used to record all data records have been documented and saved. Changes to the configurations at each site were recorded on the on-site computer in a “Readme” file. All files and programs on each DAS were copied to CDs and archived after the program.

The DAS design, its setup procedures, and its operation are described in the SOP in Appendix A.20. The major system features, operational issues encountered in CRPAQS, and a list of the parameters recorded on the DAS and uploaded to STI are included below.

The major features of the DAS include the following:

- The DAS was based on standard PC hardware (500 MHz Pentium III or faster) using Windows NT4 (multi-tasking, fully preemptive OS). Newer versions are capable of running on Windows 2000 Pro.
- DAS software was coded using National Instruments LabVIEW.
- Analog instrument inputs and digital input/output (I/O) were provided using National Instruments Multi-I/O PCI board.
- Serial instrument inputs were accommodated using standard Windows COM ports or ViewpointUSA COM port PCI boards.
- The number of analog and serial inputs was expandable and limited only by the number of motherboard adapter slots available.
- The DAS can send periodic serial commands to query instruments for data in addition to accepting asynchronous serial data.
- In addition to the analog and serial instrument outputs, the DAS can input, output, and record digital information for use to identify various status codes or events and to control relays to run automatic calibrations. These capabilities include
  - 8 bits of digital input (potentially expandable),
  - 16 bits of digital output with optional, electrically isolated control relays (expandable), and
  - 16 additional bits of internal controls to set data status codes indicating zeros, spans, etc.
- Linear scaling can be performed on all analog or serial data to apply calibrations or change scales.
- The DAS recorded all data from each serial instrument into a daily raw data file as they were received. A similar file of one-minute average raw analog input voltages was generated for each analog instrument. Collectively, these files represented all the raw incoming data each day and were stored on the on-site DAS.
- In addition, a running file of concentrations and other data of interest was generated each day for each site. This file was updated once per minute and included a record for each minute. The one-minute records included one-minute averages of the analog data, one-minute averages of serial data that were received more than once per minute, data values received during the minute for data received less than once per minute (e.g. five minutes or hourly), and associated operational codes (0=ambient measurement, 7=instrument calibration, 9=missing data point). These files were archived on the DAS and were used to create files for automatic upload to the STI data archive.
- The DAS was able to parse each serial record received directly into the running station-wide data file. The parser was able to identify particular fields of data to extract from the raw data file and copy into the running files. Typically, diagnostic data and instrument measurement values were parsed and copied into the running files. The benefit of this was that the raw data files could be maintained for detailed information when needed,

and the information maintained in the running files (and uploaded daily to the STI CRPAQS archive) could be more limited and focused.

- After midnight each day, a “Recent” file was created for upload to STI. This file included the running station file of one-minute data for the prior day and as many days prior to that as desired. For most sites, the last three days of data were sent each day, so that if a day’s data transmission were missed, the transmission for the next day would include the missing data. This system allowed automatic data recovery when a problem occurred over a weekend and was detected on Monday. For sites with slow data transmission, only one day of data was sent automatically. Data from missed transmissions were recovered manually by calling the site and downloading the data manually.
- Calibration routines can be programmed to control automated or manual processes such as instrument zero/spans or periodic samplers. These calibrations are scheduled in the .ini file and typically occurred after midnight during CRPAQS.
- Various real-time numeric and graphical data displays are available (see Appendix A.20 for examples).
- Remote control access to the DAS is available using pcAnywhere software via telephone line or broadband Internet connection.
- All settings are included in a “CRPAQS.ini” text file. Differences among the instruments at each CRPAQS site are only apparent in this file.
- The DAS was programmable (using NT/2000 or a third-party scheduler) to initiate a dial-up or Internet connection to the STI CRPAQS server on a nightly basis. Upon connection, the DAS scheduler sent the “Recent” file and specific data files that were requested by study participants.

In general, the DAS usually functioned as designed, although it suffered from some bugs and limitations, as would be expected from new software. During the program, bug fixes and revisions improved the operation and functionality of the program, resulting in a very robust and capable software tool.

- At moderately instrumented sites, including BOD, M14, SDP, SJ4, WAG, and WGT, the data system was never challenged to the point where it was unable to perform as designed. However, at other sites, the capabilities of the data system were constantly challenged, and at times it was unable to perform tasks as designed. At times, calibration routines were not initiated, and instruments were queried for information on a different schedule than designed. On some occasions, the data systems needed to be rebooted, but this was only an issue at ANGI and BAC, the sites with the heaviest instrumentation. Memory leaks in NT4 contributed to the slow degradation of DAS operation that eventually required these reboots. This situation has been corrected in subsequent DAS applications under Windows 2000 Pro. This issue was considered to be a nuisance rather than a problem and was addressed on an as-needed basis.

2.4.2 Measurement Parameters

The measurement and diagnostic parameters that were output from each continuous gas-phase instrument and entrained into the on-site DAS are listed in **Table 2-5**. Similar information was entrained from the continuous PM instruments and is listed in **Table 2-6**. The parameters that were parsed and uploaded daily to the STI archive are noted as well. These parameters were reviewed daily as a part of normal operations during the study using the STI CRPAQS data web-interface. They were also stored at STI in a database and were easily available for review, display, and processing. No parameters were recorded on the DAS from the non-continuous PM samplers.

Table 2-5. Parameters recorded from the continuous gas-phase instruments.

ID	Measurement and Method	Parameter	Instrument File on DAS	STI Archive
O	$NONO_y$ using the Thermo Environmental Instruments 42CY NO_y	NO concentration (ppb)	x	x
		NO_y concentration (ppb)	x	x
		OP[a] code	x	x
		Other diagnostics including temperatures, pressures, and flows	x	
P	O_3 using the Advanced Pollution Instruments 400A Ozone	O_3 concentration (ppb)	x	x
		OP code[a]	x	
		Other diagnostics including temperatures, voltages, and flows	x	
R	HNO_3 using the Thermo Environmental Dual Converter 42C/Y	NO_y minus HNO_3 (ppb)	x	x
		NO_y (ppb)	x	x
		OP code[a]	x	x
		Other diagnostics including temperatures, pressures, voltages, and flows	x	
Y	SO_2 using the Thermo Environmental 43S	SO_2 (ppb)	x	x
b	PAN/NO_2 using the CE-CERT instrument	NO_2 concentration (ppb)	x	x
		PAN concentration (ppb)	x	x
		Baseline area (ppb*s)	x	x
		Mode	x	x
		Other area counts and diagnostics	x	
Cal	Gas-phase calibration using the Environics 9100 Calibrator	Total gas flow (LPM)	x	x
		Actual gas concentration (ppb)	x	x
		Target ozone concentration (ppb)	x	x

[a] An OP code indicates the operational status of an instrument; it identifies calibrations and other diagnostic operations.

Table 2-6. Parameters recorded from the continuous PM instruments.

ID	Measurement and Method	Parameter	Instrument file on DAS	STI Archive
A	Light scattering using the Radiance Research M903 Integrating Nephelometer	RH (%)	x	x
		b_{sp} measured in sample mode (mM^{-1})	x	x
		b_{sp} measured in calibration mode (mM^{-1})	x	x
		Lamp voltage (V)	x	x
G-1	$PM_{2.5}$ black carbon using the Anderson Instruments AE1X Aethalometer	Black carbon concentration - NIR at 880nm (ug/m^3)	x	x
		Instrument flow (LPM)	x	x
		Sensing beam zero signal (V)	x	x
		Reference zero signal (V)	x	x
		Reference balance signal (V)	x	x
		Fraction of flow diverted	x	
		Attenuation at 880nm	x	
		Other diagnostics	x	
G-2	$PM_{2.5}$ black carbon using the Anderson Instruments AE3X Aethalometer	Black carbon concentration - NIR 950nm (ug/m^3)	x	x
		Black carbon concentration - NIR 880nm (ug/m^3)	x	x
		Black carbon concentration - red 660nm (ug/m^3)	x	x
		Black carbon concentration - yellow 590nm (ug/m^3)	x	x
		Black carbon concentration - green 571nm (ug/m^3)	x	x
		Black carbon concentration - blue 450nm (ug/m^3)	x	x
		Black carbon concentration - UV 350nm (ug/m^3)	x	x
		Instrument flow (LPM)	x	x
		Others including attenuations & diagnostics	x	
H	$PM_{2.5}$ organic and elemental carbon using the Rupprecht and Patashnick 5400 OC/EC	Organic carbon concentration (ug/m^3)	x	x
		Total carbon (organic & elemental) concentration (ug/m^3)	x	x
		Afterburner A temperature (C)	x	x
		Afterburner B temperature (C)	x	
		Instrument flow actual (LPM)	x	x
		Instrument flow setpoint (LPM)	x	
		Sample volume actual (L)	x	x
		OP code[a]	x	x

[a] An OP code indicates the operational status of an instrument; it identifies calibrations and other diagnostic operations.

Table 2-6. Parameters recorded from the continuous PM instruments.

ID	Measurement and Method	Parameter	Instrument file on DAS	STI Archive
I-1	Particle sizing using the Climet Instruments CI-500 Spectro.3; 0.3-10 µm	Instrument flow (LPM)	x	x
		Number count 0.3-0.4 um (counts)	x	x
		Number count 0.4-0.5 um (counts)	x	x
		Number count 0.5-0.63 um (counts)	x	x
		Number count 0.63-0.8 um (counts)	x	x
		Number count 0.8-1 um (counts)	x	x
		Number count 1-1.3 um (counts)	x	x
		Number count 1.3-1.6 um (counts)	x	x
		Number count 1.6-2 um (counts)	x	x
		Number count 2-2.5 um (counts)	x	x
		Number count 2.5-3.2 um (counts)	x	x
		Number count 3.2-4 um (counts)	x	x
		Number count 4-5 um (counts)	x	x
		Number count 5-6.3 um (counts)	x	x
		Number count 6.3-8 um (counts)	x	x
		Number count 8-10 um (counts)	x	x
		Number count >10 um (counts)	x	x
I-2	Particle sizing using the Particle Measuring Systems Lasair; 0.1-2 µm	Instrument flow (LPM)	x	x
		Number count 0.1-0.2 um (counts)	x	x
		Number count 0.2-0.3 um (counts)	x	x
		Number count 0.3-0.4 um (counts)	x	x
		Number count 0.4-0.5 um (counts)	x	x
		Number count 0.5-0.7 um (counts)	x	x
		Number count 0.7-1 um (counts)	x	x
		Number count 1-2 um (counts)	x	x
		Number count >2 um (counts)	x	x
I-3	Particle sizing using the TSI SMPS; 0.01-0.4 µm	Date and time	x	x
		Sample flow (LPM)	x	x
		Diagnostic parameters including pressure (atm) and sheath flow (LPM)	x	x
		dN/d log Dp for 53 size bins (count/d log Dp)	x	x
		OP code[a]	x	x
		Other diagnostics	x	
J,K	$PM_{2.5}/PM_{10}$ mass using the Met One Instruments 1020 BAM	Total mass (ug/m^3)	x	x
		Instrument flow (LPM)	x	x
		Error code	x	
		OP code[a]	x	x

[a] An OP code indicates the operational status of an instrument; it identifies calibrations and other diagnostic operations.

Table 2-6. Parameters recorded from the continuous PM instruments.

ID	Measurement and Method	Parameter	Instrument file on DAS	STI Archive
Q	$PM_{2.5}$ nitrate using the Rupprecht and Patashnick 8400N	Date and time (PST)	x	x
		Ambient temperature (C), pressure (atm), and relative humidity (%)	x	x
		Conditioned relative humidity (%)	x	x
		Enclosure temperature (C)	x	x
		Diagnostic pressures including sample (atm), analysis dP (“H_2O), and cell (“Hg)	x	x
		Diagnostic flows including sample (LPM), cross (LPM), and analysis (LPM)	x	x
		Diagnostic times including sample (s), read 1 (s), and flash (ms)	x	x
		Diagnostic integration parameters including baseline area (ppb*s) and flash area (ppb*s)	x	x
		Applied factors including conversion factor (ppb*s/ng) and theoretical conversion (%)	x	x
		Ambient NO_x concentration (ppb)	x	x
		Ambient NO_3 concentration (ug/L)	x	x
		OP code[a]	x	x
T	$PM_{2.5}$ sulfate using the Rupprecht and Patashnick 8400N	Date and time (PST)	x	x
		Ambient temperature (C), pressure (atm), and relative humidity (%)	x	x
		Conditioned relative humidity (%)	x	x
		Enclosure temperature (C)	x	x
		Diagnostic pressures including sample (atm) and analysis dP (“H_2O)	x	x
		Diagnostic flows including sample (LPM), cross (LPM), and analysis (LPM)	x	x
		Diagnostic times including sample (s), read 1 (s), and flash (ms)	x	x
		Diagnostic integration parameters including baseline area (ppb*s) and flash area (ppb*s)	x	x
		Applied factors including conversion factor (ppb*s/ng) and theoretical conversion (%)	x	x
		Ambient SO_2 concentration (ppb)	x	x
		Ambient SO_4 concentration (ug/L)	x	x
		OP code[a]	x	x

[a] An OP code indicates the operational status of an instrument; it identifies calibrations and other diagnostic operations.

2.5 INSTRUMENT CALIBRATION

All continuous and semi-continuous instruments at the CRPAQS Anchor sites underwent routine calibration although at varying frequencies. Calibration techniques used to assess instrument performance included self-calibration, external calibration using an on-site calibrator, or external calibration using a roving transfer standard.

2.5.1 Philosophy of Calibrations

The calibration philosophy was that all continuous and semi-continous instruments should be calibrated or have their calibrations checked at installation, on a routine basis, and at decommissioning. Primary standards were used when available. Research instruments and newly commercialized instruments were calibrated on a more frequent basis than field-tested instruments. The actual calibration techniques used for each instrument depended on the measurement method. The filter, cartridge, canister and other grab samplers that were provided by other contractors were calibrated before installation by their owners, and their calibrations are not discussed here.

Gas-phase instruments were calibrated using an on-site calibration system and a roving transfer standard. Calibrations using the roving transfer standard were performed after installation, every quarter, and at the end of the study. Nightly calibration checks were performed using the on-site calibrators, zero-air generators (Aadco) and matrix-air systems (an alternate method of generating purified air that presumably replicated ambient air without the pollutants). Both the roving and on-site calibrators were Environics 9100s that required certified gas standards. The on-site gas calibrators were programmed to perform automatic nightly zeros and spans and bi-weekly manually started, multi-pollutant calibration checks, injecting calibration gases directly into the outside ambient-air instrument inlets through a calibration manifold system. The roving transfer standard was used to perform the installation, quarterly, and decommissioning multi-point calibrations, routing the calibration gas directly to the back of the instruments. All calibrations with the roving calibrator were performed manually and required the on-site calibrator to be temporarily disconnected.

The continuous and semi-continuous PM instruments were calibrated using built-in and/or external calibrators. Some of the instruments had software-driven internal calibration systems. Some of these internal systems operated automatically, and some were manually enabled. Most instruments were also calibrated using external methods by the site operator.

The calibration methods and frequencies are described in the next section.

2.5.2 Calibration Techniques and Frequency

Table 2-7 lists the types and frequencies of calibrations that were performed at the CRPAQS Anchor sites.

Table 2-7. Calibrations performed at CRPAQS Anchor sites.

Page 1 of 2

ID	Measured Parameter	Every hour	Four per day	Every day	Every week	Every 2 weeks	Every month	Every Quarter
A	Light Scattering (Integrating nephelometer)				Filter and CO_2		Filter and SUVA	
G-1	$PM_{2.5}$ black carbon (1-wavelength Aethalometer)						Optical test, flow cal	
G-2	$PM_{2.5}$ black carbon (7-wavelength Aethalometer)						Optical test, flow cal	
H	$PM_{2.5}$ OC/EC Carbon						Gas cal, flow cal	
I-1	Particle sizing (Climet OPC); 0.3 – 10 µm				(PSL cal)[a]		PSL cal	flow cal
I-2	Particle sizing (PMS LASAIR OPC); 0.1 – 2 µm				(PSL cal)[a]		PSL cal	flow cal
I-3	Particle sizing (TSI SMPS); 0.01 – 0.4 µm				(PSL cal)[a]		PSL cal	flow cal
J	PM_{10} mass (BAM)	Auto mass cal					Flow cal	
K	$PM_{2.5}$ mass (BAM)	Auto mass cal					Flow cal	
O	NO/NO_y		External matrix zero	Auto external zero/span		Zero, NO, NO_2, NH_3, HNO_3[b] cal		Multipoint NO and NO_2 cal
P	O_3			Auto zero/span				Multipoint O_3 cal
Q	$PM_{2.5}$ nitrate			Auto gas cal (every 2 days)		Aqueous standard cal, filter, flow cal		
R	HNO_3		External matrix zero	Auto external zero/span		Zero, NO, NO_2, NH_3, HNO_3[b] cal		Multipoint NO and NO_2 cal

[a] During Winter Study, only for Angiola trailer instruments

[b] The HNO_3 calibrations were attempted using a permeation tube, but the system never worked properly.

Table 2-7. Calibrations performed at CRPAQS Anchor sites.

ID	Measured Parameter	Every hour	Four per day	Every day	Every week	Every 2 weeks	Every month	Every Quarter
T	$PM_{2.5}$ sulfate			Auto gas cal (every 2 days)		Aqueous standard cal, filter, flow cal		
Y	SO_2			Auto external zero/span				Multipoint SO_2 cal
b	PAN/NO_2 (chromatography, luminol detection)	Internal each 2 hrs	External matrix zero	Auto external zero/span		Zero, NO, NO_2, NH_3, HNO_3[b] cal		Multipoint NO and NO_2 cal

[a] During Winter Study, only for Angiola trailer instruments
[b] The HNO_3 calibrations were attempted using a permeation tube, but the system never worked properly.

A brief description of the types of calibrations performed by STI for each continuous instrument is provided below. Some of the techniques are described in more detail in the instrument SOPs.

Integrating Nephelometer

The nephelometers were calibrated manually using gases with known light-scattering coefficients. The instruments were calibrated to measure light-scattering by particles. They were set to read zero when filled with particle-free air. Up-scale readings were provided by CO_2 and SUVA, as described in the SOP in Appendix A.2. Zero-air/CO2 calibrations were performed weekly; zero/SUVA calibrations were done monthly.

Aethalometers

The instrument response was checked monthly using a filter and an optical test standard. An external filter at the inlet was used to create a zero-air signal. The internal optical absorption test standard was inserted in the optical chamber to create span references at two levels of absorption (particle concentration). The flow rate was also measured at the inlet on a monthly basis at zero flow and at 6.9 l/m. More information on the calibration procedures is included in the Aethalometer instrument manual.

OC/EC

The OC/EC works by oxidizing carbon to CO_2 and then measuring the CO_2 produced. The instrument was calibrated monthly using zero air and two concentrations of CO_2 (400ppmv and 2400ppmv). The OC/EC instrument calibration software was initiated manually by the site operator and controlled the injection of calibration gases into the LI-COR detector.

The OC/EC flow controllers were also calibrated on a monthly basis. The target sample flow rate (16.7 lpm) and flow controller calibration were evaluated using a BIOS flow meter. A flow restrictor was placed at the inlet of the instrument to test for leaks. Some additional information on calibration of the OC/EC is included in Appendix A.4

Particle Counters

The particle counter particle-sizing and sample-flow rate were supposed to be checked monthly. Both tests were performed manually by the site operator. The sizing checks were made by nebulizing and injecting five sizes of polystyrene latex (PSL) into to the sizing-system manifold. The sizes were chosen to provide one or two particle sizes to be measured by each instrument. The sample flow rates of the particle counters were measured at the inlets of the individual instruments using a Gilibrator primary flow standard. Leak checks were performed on all three types of instruments by placing a HEPA filter on the sample inlets and verifying that zero counts were recorded. The calibration procedures are described in more detail in the SOP in Appendix A.5.

As a result of reliability problems, the ANGI particle counters' size cuts were checked with PSL on a weekly, instead of monthly, basis during the Winter IOP.

BAMs

The BAMs were automatically calibrated between samples on a 1-hr basis. The test involved the sequential measurement of the mass of a blank portion of the filter tape and the mass of a membrane that simulated beta absorption equivalent to 200 $\mu g/m_3$ of ambient aerosol. External flow checks were performed at the instrument inlet on a monthly basis (rather than each two months as stated in the original SOP). A BIOS flow meter was attached to the sharp-cut cyclone inlet and used to check the sample flow rate and the accuracy of the instrument flow meter. The instrument was also checked for leaks by restricting the flow at the inlet. The BAM calibrations are discussed further in Appendix A.6.

NO/NO_y, HNO_3, and PAN/NO_2

The NO/NO_y monitor, the dual-converter HNO_3 monitor, and the PAN/NO_2 monitor were calibrated using a shared system. Matrix-air zeros (using Purafil-scrubbed ambient air) were performed automatically each day at 0600, 1100, 1600, and 2100 PST using the Environics calibrator and matrix-air system installed at each site. In addition, span checks at 90 ppb concentrations of NPN and NO and zero checks were performed automatically each night with the Environics calibrator and dry zero air system (Aadco). A span using 60 ppb of NO_2 generated by GPT was also performed nightly. The gases for the daily zero and span checks were delivered directly to the ambient-air inlets of the instruments.

On a bi-weekly basis, the site operators manually started a pre-programmed calibration cycle for these instruments using the on-site calibration systems and delivering gases to the ambient-air inlets. These calibrations included matrix and dry-air zeros, 90 ppb span checks with NPN, NO, and NH_3, a 450-ppb NO span check, and a 350-ppb GPT NO_2 span and converter-efficiency check. A 20-ppb HNO_3 calibration using a permeation tube was also performed.

At installation, decommissioning, and on a quarterly basis, full multipoint calibrations of NO were performed along with a 350-ppb GPT NO_2 span and converter-efficiency check. The quarterly gas calibrations were performed with the roving Environics 9100 transfer standard. Sample flow rate checks were performed at the same time using the Gilibrator primary flow standard.

In addition to the above-mentioned calibrations using the on-site calibrator, the PAN/NO_2 monitor performed automatic calibrations using a scrubbed ambient zero gas and a 50-ppbv NO_2 span gas to the back of the instrument every two hours.

One exception to this schedule was the NO/NO_y on the ANGT tower which was not set up for the bi-weekly multi-gas calibrations.

The NO/NO_y, HNO_3, and PAN/NO_2 external calibrations are described in more detail in the SOP in Appendix A.7. The PAN/NO_2 internal calibrations are described in an SOP from a prior project in Appendix A.12.

Ozone

Nightly zero-air and single-point calibration checks (at 80 ppb) were performed automatically using the on-site Environics systems. The gases were injected directly into the ambient-air inlet. At installation, decommissioning, and on a quarterly basis, the ozone monitors were calibrated at five concentrations using the roving transfer standard (Environics 9100). The gases for the quarterly calibrations were input at the backs of the instruments.

The one exception to this schedule was the Angiola Tower ozone monitor which was only calibrated at the beginning and end of the Winter Study using the roving Environics calibrator.

Nitrate and Sulfate

The nitrate and sulfate systems have similar designs and calibration approaches. Both instruments have software-controlled and -actuated internal calibration methods. These automatic calibrations were performed every other day and involved the injection of purified (zero) and span gas into the collection cell of the instrument. The nitrate and sulfate instruments used N_2 and air, respectively, for the zero gas; and 5-ppmv NO and 1-ppmv SO_2, respectively, for the span gas. Every two weeks, both systems were also calibrated manually by the site operator using aqueous standards applied directly to the flash strip in the collection cell. The aqueous standards were solutions of ammonium nitrate (nitrate) and ammonium sulfate in oxalic acid (sulfate). Both instruments were calibrated using four volumes (loadings) of the solution and a single volume (loading) of deionized water. At the same time as the aqueous standard calibrations, a “field blank” test was performed by inserting a Teflon filter downstream of the inlet cyclone. The sample flow meter and flow rate (set point 6.7 lpm) was also checked on a biweekly basis using the Gilibrator primary flow standard

The calibration procedures and concentrations are included in the SOPs for nitrate and sulfate in appendices A.9 and A.10 respectively.

Sulfur Dioxide

Automatic zero and span (40 ppb) checks were performed nightly using the on-site Environics system. The nightly calibration gases were injected into the ambient air inlet. The SO_2 monitor was operated only during the Winter Study. At installation and decommissioning, the SO_2 monitor was calibrated at five concentrations using the roving transfer standard (Environics 9100). During these calibrations, the gases were input to the back of the instrument.

The calibration procedures are described in Appendix A.11.

2.5.3 Calibrator Certification

In the cases where primary or secondary standards are used for calibrations, the maintenance and certification of the calibrators becomes an issue.

The primary temperature and pressure standards were certified at the factory for approximately a year. Because of this no certification of these standards was needed during the study. The primary flow standards were also certified at the factory for approximately a year and required no further certification during the study. Commonly available temperature and pressure standards and BIOS Dry-Cell and Sensidyne Gilibrator flow standards were used during CRPAQS.

The secondary (transfer) standard for ozone (and $NO/NO_2/SO_2$) (Environics 9100) was certified for flow and ozone generation on a quarterly basis as recommended by the ARB. A Dasibi 1008-PC was used as the primary ozone standard. This instrument was owned and operated by STI. Performance criteria given by the ARB were loosely followed. Guidance in the interpretation of the ARB criteria was given by CE-CERT (NO_y, HNO_3, and PAN/NO_2 measurement expert). The transfer standard was certified using the procedures detailed in a recertification SOP not included here. A summary of the key procedures follows.

For both initial certification and recertification, the following performance criteria were permitted:

Slope +/- 5% (+/- 2% attained)

Intercept +/- 1% of full scale (+/- 0.5% attained)

Correlation $R^2 > 0.9999$

The numbers in parentheses are the percentages actually attained by both the flow controller and the ozone generator in the six-point, six-day certification described below.

Initial certification of a transfer standard

Six-point flow calibrations were performed on each flow meter at 95, 75, 50, 25, 10, and 5% of full scale and were repeated for six days in a row. Calibrations were performed using certified primary temperature, pressure, and flow standards.

Six-point ozone generator calibrations were performed at 100, 80, 60, 30, 15, and 5% of full-scale and were repeated for six days in a row. Calibrations were performed using STI's certified primary ozone standard. The six daily calibrations were required to be within the above tolerances of each other.

Recertification of a transfer standard

A single six-point flow calibration was performed each quarter on each flow meter at 95, 75, 50, 25, 10, and 5% of full scale. Calibrations were performed using certified primary temperature, pressure, and flow standards.

A single six-point ozone generator calibration was performed at 100, 80, 60, 30, 15, and 5% of full-scale repeated for one day. Ozone calibrations were performed using the certified primary ozone standard.

Calibrator performance for recertifications should be within the performance criteria given above when compared to the five prior calibrations.

The roving transfer standard was a certified instrument that was recertified using the procedures described in the SOP and summarized above. The on-site calibrators were checked quarterly using the transfer standard by comparing the instrument response when calibrated by the on-site calibrator and when calibrated by the roving transfer standard. They were also evaluated using primary flow standards at least once during the field study.

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3. SITE CHARACTERISTICS AND INSTRUMENTATION

This section provides summary descriptions of the CRPAQS Anchor sites and lists the actual instruments that were operated at each site. The site addresses and coordinates are listed in Table 1-1. The sites are discussed in alphabetical order. Characteristics of each site are discussed first, including the location of the site relative to local sources that might influence the measurements, local climate, the site construction and amenities, and issues that affected operation of instruments at the site. Photos of the sites and instrument installations are included in the “Site Characteristics” sections for each site. Additional information on the layout and surroundings of each site can be found in McDade (2002).

The instrumentation located at each site is documented next. A quick-reference figure that shows the operational period and an indicator of data recovery for each measurement type is included for each site. The figures are followed by lists of the serial numbers and operational dates of the instruments installed at each site.

3.1 ALTAMONT (ALT1) – ANNUAL ANCHOR SITE

3.1.1 Site Characteristics

Details of the Altamont (ALT1) site’s physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-1** shows the site shelter and surrounding area.

<u>Site location:</u>

- Site is at an elevation of 345 m (1161 ft) in a remote uninhabited location.
- Site is co-located with a meteorological monitoring tower and in close proximity to a major freeway (I-580) and power-generation windmills (transport corridor).
- Site is within 0.25 mile of major highway with heavy traffic and congestion during peak commute hours.
- Site located in elevated foothills with native and non-native grassland communities being predominant.

<u>Climate</u>:

- Site located in a major east-west trending transport corridor subject to fog in the fall through winter with moderate winds prevalent throughout most of the year. Hot and dry in the summer with most annual precipitation occurring November-March.

<u>Site construction and amenities:</u>

- The only instrument at this site was mounted in fiberglass shelter that had limited space and was not level.
- Shelter did not have adequate weather protection and had no climate control.
- There was no phone access at site.

Major issues:

- Construction - Lack of weather resistance allowed for leaking into enclosure along inlet and resulted in frequent BAM tape-transport errors.
- Space - Limited space required BAM to be mounted sideways in the enclosure which complicated routine instrument maintenance.
- Power - Inconsistent power to the instrument caused internal data-logger BAM errors and resulted in greater data loss than at sites with an onsite data-acquisition system.
- Access - Site access limited because of occasional gate lock removal by property-owner.

Figure 3-1. Photos of Altamont (ALT1) annual Anchor site. Left is shelter with BAM inside; right is view from site.

3.1.2 Site Measurements

Figure 3-2 and **Table 3-1** detail the operation period of ALT1 annual Anchor site-instruments and the instruments operated at the ALT1 annual Anchor site.

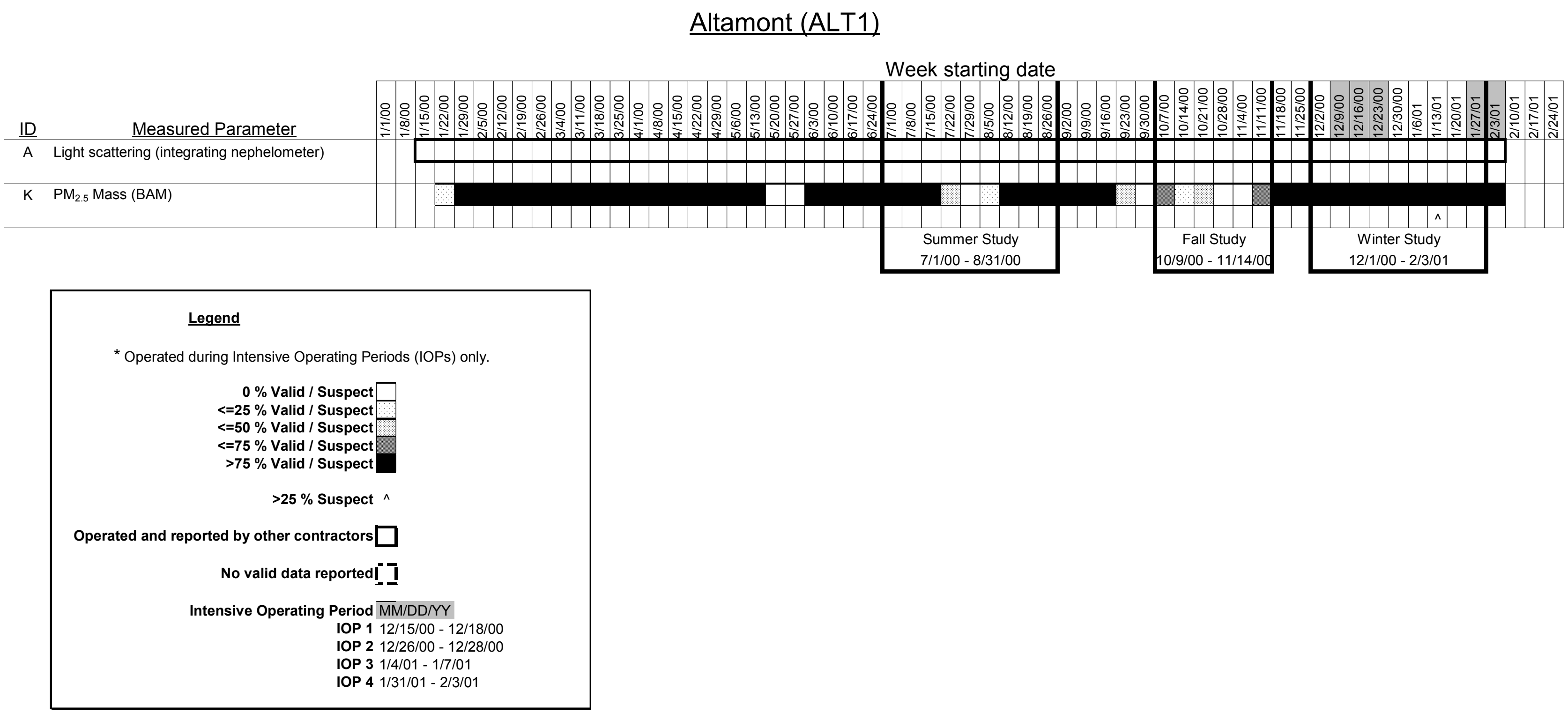


Figure 3-2. Operation period of ALT1 annual Anchor-site instruments.

Table 3-1. Instruments operated at the ALT1 annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
A	Light scattering	Radiance Research	M903 Nephelometer	0233	010149	1/19/00	2/08/01
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x4946	010117	1/19/00	12/9/00
K*	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y2133	010621	12/9/00	2/08/01

* The original instrument was replaced with this instrument.

3.2 ANGIOLA (ANGI) – ANNUAL ANCHOR SITE

3.2.1 Site Characteristics

Details of the Angiola (ANGI) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-3** shows the site's physical layout.

<u>Site location:</u>

- The site is located in a flat arid remote location between Interstate 5 and U.S. 99 approximately 10 miles south of Corcoran and 3 miles west of Alpaugh.
- The site is on a parcel surrounded by a cotton field located in a region of intensive cotton production.

<u>Climate:</u>

- The site elevation is almost at sea level in an arid environment with annual precipitation less than seven inches. It is hot and dry in the summer with most annual precipitation occurring from November through March. The site is subject to summer temperatures often above 110°F and to fog episodes in the fall through winter.

<u>Site construction and amenities:</u>

- The site is in a temporary trailer with a deck constructed above it to hold the inlets and various samplers.
- The site is constructed on a graveled, fenced parcel with two adjacent trailers and a 100-m tower with the closest active cotton production 12 ft from the trailer.
- Electrical power and phone lines had to be brought in to the site.

<u>Major issues:</u>

- Power – The site commonly experienced brownouts and blackouts that compromised the data and affected the operation of particular instruments ($PM_{2.5}$ OC/EC, $PM_{2.5}$ Black Carbon, NO_y, SMPS, BAM).

- Phone – Phone service to the site was at the end of the line. STI was frequently unable to obtain remote access to the data acquisition system and had to resend data when service was restored.
- Agriculture – Agricultural sources (dust, vehicle exhaust) were commonly observed in the data. These sources of emissions (and insects) caused dramatic wear and tear on the instruments and required more invasive and more frequent maintenance of the instruments to be performed.

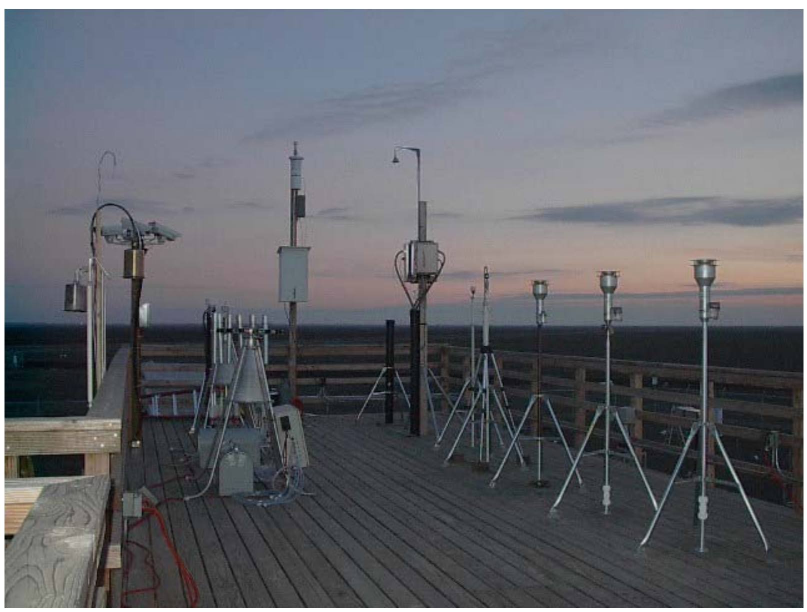
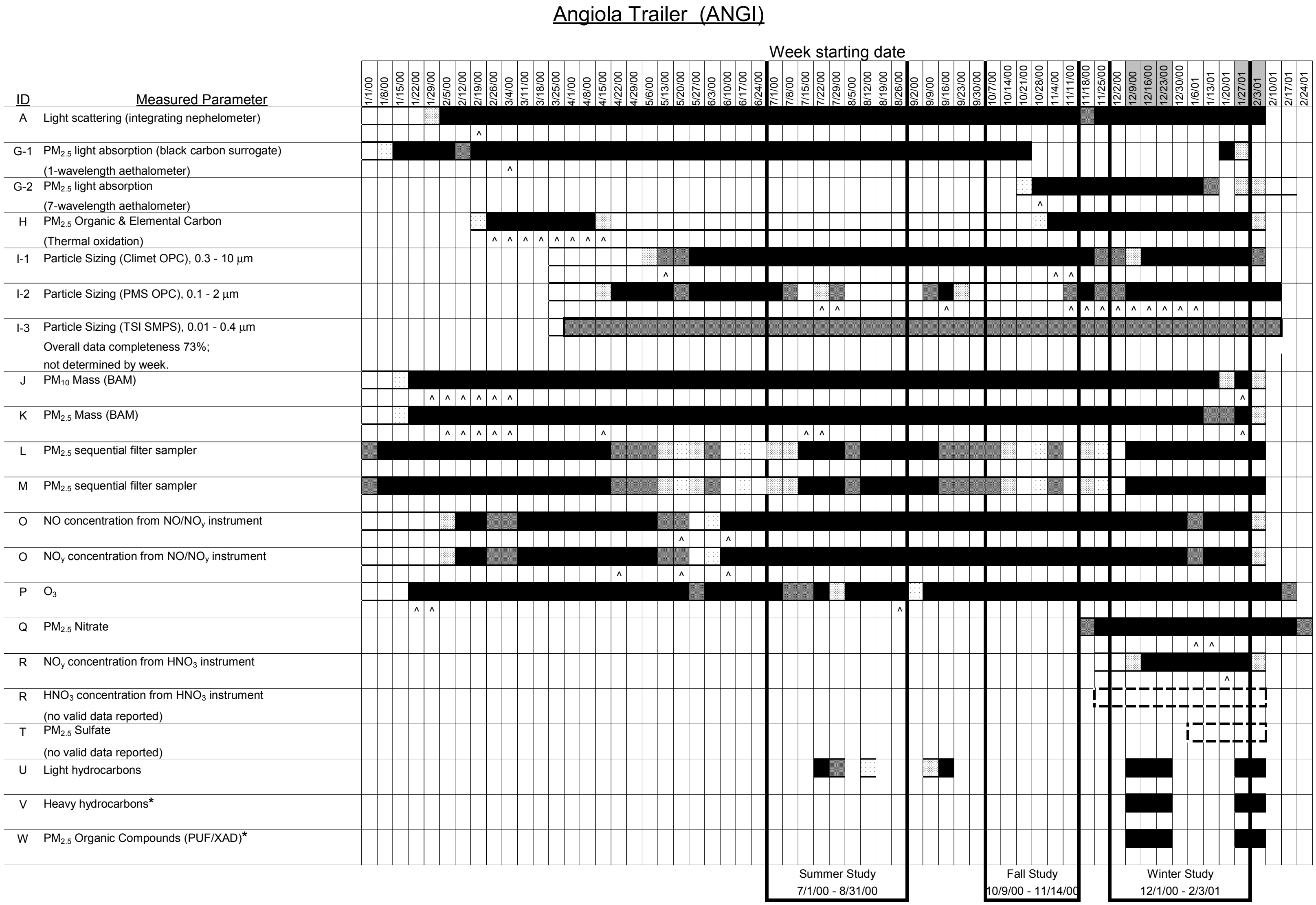


Figure 3-3. Photos of Angiola (ANGI) annual Anchor site. Top left is view of trailer and tower, top right is Anchor-site trailer, bottom is trailer roof deck.

3.2.2 Site Measurements

Figure 3-4 and **Table 3-2** detail the operation period of ALT1 annual Anchor site-instruments and the instruments and samplers operated at the ALT1 annual Anchor site.



3-4a. Operation period of ANGI annual Anchor site-instruments (page 1).

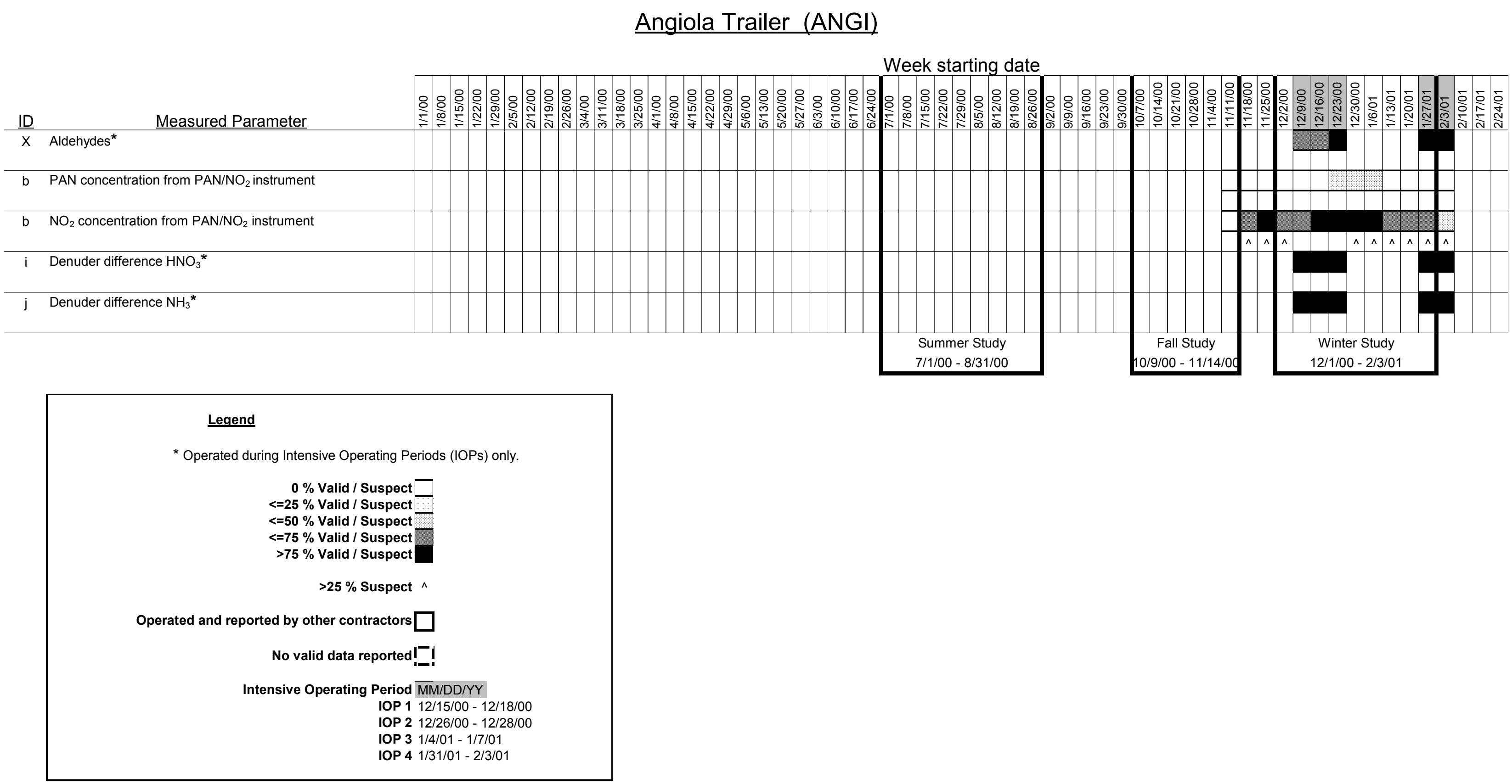


Figure 3-4b. Operation period of ANGI annual Anchor site instruments (page 2).

Table 3-2. Instruments and samplers operated at the ANGI annual Anchor site.

Page 1 of 2

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS1	010633	12/13/99	5/22/00
*	DAS	Immecore	NA	CRPAQS8	010212	5/22/00	3/1/01
	Calibrator	Environics	9100 Calibrator	2573	010209	12/11/99	2/12/01
	Zero air generator	Aadco	737R-11A Zero air generator	2653	010130	12/11/99	2/12/01
A	Light scattering	Radiance Research	M903 Nephelometer	0192		12/28/99	5/9/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0262	010259	5/9/00	2/7/01
G-1	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	228:25R6	010119	12/22/99	10/26/00
G-2	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	257:62P2	010247	10/26/00	1/19/01
G-1*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	229:32U2	010120	1/20/01	1/29/01
G-2*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	257:62P2	010247	1/30/01	2/24/01
H	$PM_{2.5}$ Organic and elemental carbon	Rupprecht & Patashnick	5400 OC/EC	B202579908	NA	NA	NA
H*	$PM_{2.5}$ Organic and elemental carbon	Rupprecht & Patashnick	5400 OC/EC	B202699912	010208	2/22/00	2/6/01
I-1	Particle sizing; 0.3-10 µm	Climet Instruments	Spectro 0.3 Optical particle counter	990247	01017?	3/30/00	8/3/00
I-1*	Particle sizing; 0.3-10 µm	Climet Instruments	Spectro 0.3 Optical particle counter	990246	010179	8/3/00	12/6/00
I-1*	Particle sizing; 0.3-10 µm	Climet Instruments	Spectro 0.3 Optical particle counter	990246	010179	12/13/00	2/8/01
I-2	Particle sizing; 0.1-2 µm	Particle Measuring Systems	Lasair 1003	12573	010201	3/30/00	2/16/01
I-3	Particle sizing; 0.01-0.4 µm	TSI	Scanning mobility particle sizer	8083	010120	4/3/00	2/16/01
J	PM_{10} mass	Met One Instruments	1020 BAM	x4152	010113	12/22/99	3/7/00
J*	PM_{10} mass	Met One Instruments	1020 BAM	x4619	010114	3/7/00	1/19/01
J*	PM_{10} mass	Met One Instruments	1020 BAM	x4619	010114	1/23/01	2/6/01

Table 3-2. Instruments and samplers operated at the ANGI annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x4619	010114	12/22/99	3/7/00
K*	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x4152	010113	3/7/00	1/19/01
K*	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x4619	010114	1/19/01	1/23/01
K*	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x4152	010113	1/23/01	2/6/01
L,M	SFS	DRI	SFS	13	DRI 605838	12/31/99	2/6/01
O	NO_y	Thermo Environmental Instruments	42C/Y Single converter	64748-345	010124	1/3/00	2/9/01
P	O_3	Advanced Pollution Instruments	400A	250	010111	1/5/00	2/21/01
Q	Nitrate Generator	Rupprecht & Patashnick	8400N	840NA2010 50006	ARB 20005529	11/8/00	3/1/01
Q	$PM_{2.5}$ Nitrate Analyzer	Rupprecht & Patashnick	8400N	56	ARB 20005528	11/8/00	3/1/01
R	HNO_3	Thermo Environmental Instruments	42C/Y Dual converter	67179-355	010438	11/26/00	2/9/01
T	Sulfate Generator	Rupprecht & Patashnick	8400S	840SA2010 10007	010221	1/11/01	2/8/01
T	$PM_{2.5}$ Sulfate Analyzer	Rupprecht & Patashnick	8400S	57	010222	1/11/01	2/8/01
U	Light hydrocarbons	OGI	Canister	?	Rasmussen	7/?/00	9/?/00
U	Light hydrocarbons	OGI	Canister	01	Rasmussen	11/19/00	2/6/01
V	Heavy hydrocarbons	DRI (two samplers)	Tenax	6X11, 6X12	010172	11/19/00	2/6/01
W	$PM_{2.5}$ organics	DRI	PUF/XAD	6	DRI 604550	11/19/00	2/6/01
X	Carbonyl	ATMAA	Sampler	21/22	ATMAA	12/15/00	2/3/01
b	PAN/NO_2	CECERT	PAN/NO_2	07	010734	11/8/00	2/9/01
c	MOUDI	MSP Corporation	100-1	MDI-227	010226	11/19/00	2/6/01
d	**MOUDI (one of two)**	MSP Corporation	100-1	MDI-228	010225	11/19/00	2/6/01
d	**MOUDI (two of two)**	MSP Corporation	100-1	MDI-229	010224	11/19/00	2/6/01
I	SGS	DRI	196433	GMZ-11	DRI 603998	11/30/00	2/6/01
J	SGS	DRI	?	HOV-07	DRI 603990	11/30/00	2/6/01

* The original instrument was replaced with this instrument.

3.3 ANGIOLA TOWER (ANG1, ANG50, ANG95) – ANNUAL ANCHOR SITE

3.3.1 Site Characteristics

Details of the Angiola Tower (ANG1, ANG50, and ANG95) site's physical features—location, climate, and construction—and issues related to the site follow. **Figure 3-5** shows the tower and its enclosures.

Site location:

- The tower was approximately 80 ft east of the Angiloa-site measurement trailer and within the gated boundary of the graveled site.

Climate:

- The site elevation was almost at sea level in an arid environment with annual precipitation less than seven inches. The site was hot and dry in the summer with most annual precipitation occurring from November through March. It was subject to summer temperatures often above 110°F. and fog episodes in the fall through winter.

Site construction:

- The instruments were installed in fiberglass enclosures which were mounted onto a 100-m tower at four positions (approximately: 50 m, 91 m, 93 m, 95 m). The enclosures were shown earlier in Figures 2-18, 2-18, and 2-20. The instruments at each level are listed in Table 1-2 and shown in the above figures.
- A carriage system allowed the staff to bring the enclosures from their normal sampling positions down to near ground level, although the enclosures remained stacked above each other and were not all accessible from the ground.
- The instruments were serviced and calibrated near ground level using a scissor lift.

Major issues:

- Data transmission – Analog signals could not be carried down the tower to the data logger without interference. As a result, digital signals were used to transmit all data for all the tower instrumentation (even the integrating nephelometer that typically used an analog signal at other sites). The nephelometer data had to be recorded internally by the nephelometer and then polled each night by the data system. The nephelometer data were not plotted on the on-site data logger display but were transmitted to STI each night for review.
- Gas supply – The nitrate instrument required a continuous supply of compressed gas for normal operation. Special reinforced 1/4" Teflon tubing and two stages of pressure regulation were used to deliver a continuous supply of nitrogen from a cylinder that was mounted at the bottom of the tower to the nitrate instrument mounted at 95 m. Calibration gas was supplied to the instrument from a small cylinder that was mounted in one of the nearby enclosures on the tower (but not the enclosure the nitrate instrument was in).

- Instrument operation – The enclosures had very basic temperature control. At first, fans continuously pulled ambient air through the enclosures for cooling. For the majority of the annual study this configuration provided a reasonable working environment for the instruments. When the winter instruments were installed, it became clear that we were no longer maintaining a reasonable working environment for the instruments because the new instruments were more sensitive and the ambient temperatures were more extreme and more variable and there was far less free space within the enclosures (taken up by new instruments). As a result, temperature control was added during the Winter Study. Temperature control was achieved using a cooling temperature switch that would activate the fan when the temperature exceeded 72°F (this is the same fan that used to run continuously.)

Figure 3-5. Photos of Angiola Tower (ANGT) annual Anchor site. Left shows enclosures at ground-level for maintenance and scissors lift. Right shows the tower with enclosures at 50 m and 95 m.

3.3.2 Site Measurements

Figure 3-6 and **Table 3-3** detail the operation period of ANGT annual Anchor site-instruments and the instruments operated at the ANGT annual Anchor site.

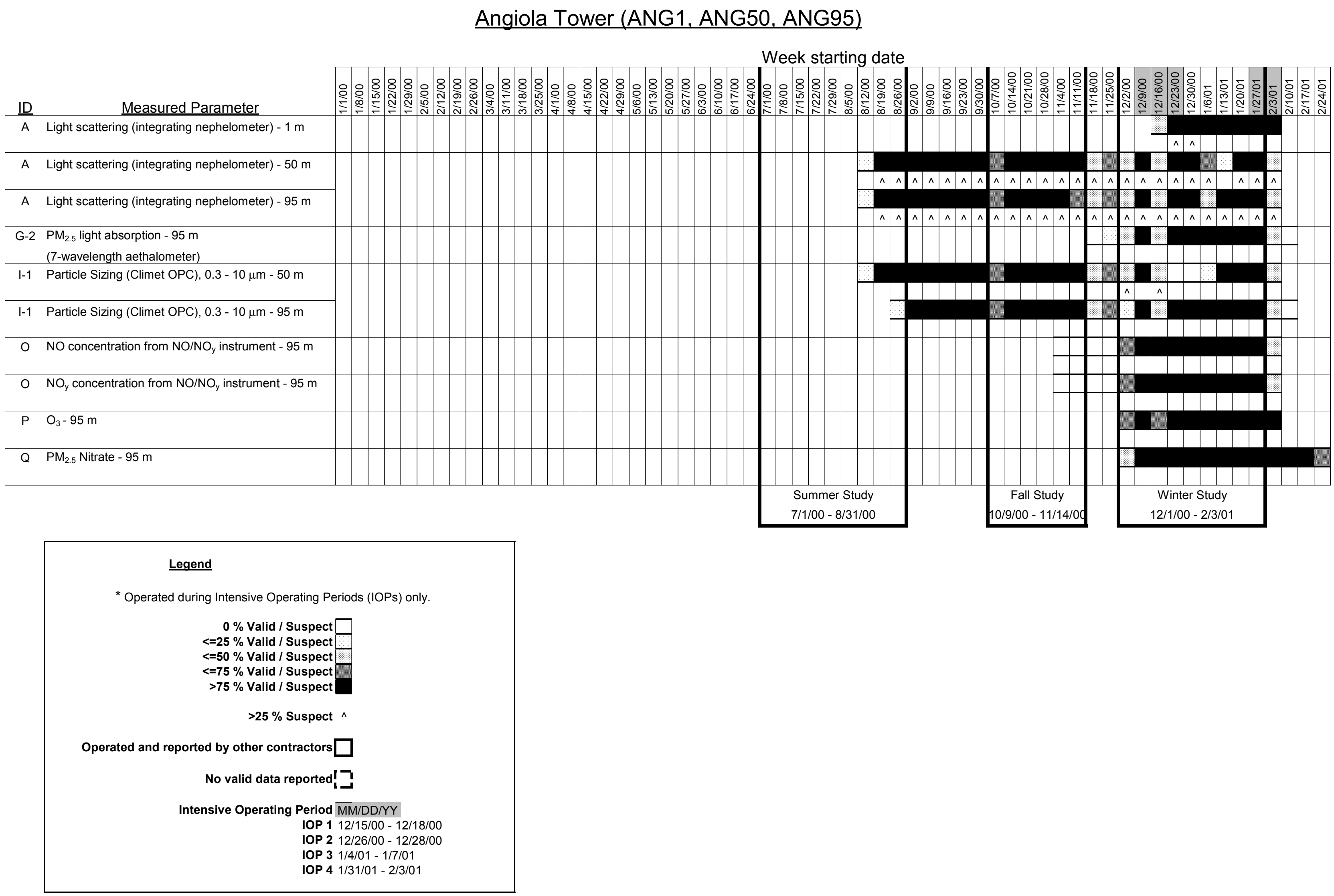


Figure 3-6. Operation period of ANGT annual Anchor-site instruments.

Table 3-3. Instruments operated at the ANGT annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
	Calibrator – Tower cal/TS	Environics	9100 Calibrator	2572	010132	12/5/00	3/1/01
A	Light scattering-1m	Radiance Research	M903 Nephelometer	0194	010133	12/15/00	2/7/01
A	Light scattering-50m	Radiance Research	M903 Nephelometer	0192	010256	8/18/00	2/8/01
A	Light scattering-95m	Radiance Research	M903 Nephelometer	0193	010255	8/18/00	2/8/01
G-2	$PM_{2.5}$ Black carbon – 95m	Andersen Instruments	AE3X Aethalometer	254:40G6	010248	11/21/00	2/24/01
I-1	Particle sizing; 0.3-10 µm; 50m	Climet Instruments	Spectro 0.3 Optical particle counter	978182	010230	8/18/00	12/5/00
I-1*	Particle sizing; 0.3-10 µm; 50m	Climet Instruments	Spectro 0.3 Optical particle counter	990247	010229	12/5/00	12/6/00
I-1*	Particle sizing; 0.3-10 µm; 50m	Climet Instruments	Spectro 0.3 Optical particle counter	990246	010179	12/6/00	12/13/00
I-1*	Particle sizing; 0.3-10 µm; 50m	Climet Instruments	Spectro 0.3 Optical particle counter	978182	010230	12/13/00	2/5/01
I-1	Particle sizing; 0.3-10 µm; 95m	Climet Instruments	Spectro 0.3 Optical particle counter	990247	010229	8/18/00	12/5/00
I-1*	Particle sizing; 0.3-10 µm; 95m	Climet Instruments	Spectro 0.3 Optical particle counter	978182	010230	12/5/00	12/6/00
I-1*	Particle sizing; 0.3-10 µm; 95m	Climet Instruments	Spectro 0.3 Optical particle counter	990247	010229	12/6/00	2/16/01
O	NO_y - 95m	Thermo Environmental Instruments	42C/Y Single converter	66393-352	010400	11/5/00	02/5/01

Table 3-3. Instruments operated at the ANGT annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
P	O_3 - 95m	Advanced Pollution Instruments	400A	377	010391	12/1/00	02/5/01
Q	$PM_{2.5}$ Nitrate Generator - 95m	Rupprecht & Patashnick	8400N	840NA20 1010004	ARB 20005556	12/4/00	3/1/01
Q	$PM_{2.5}$ Nitrate Analyzer - 95m	Rupprecht & Patashnick	8400N	57	ARB 20005555	12/4/00	3/1/01

* The original instrument was replaced with this instrument.

3.4 BAKERSFIELD CALIFORNIA AVENUE (BAC) – ANNUAL ANCHOR SITE

3.4.1 Site Characteristics

Details of the Bakersfield California Avenue (BAC) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-7** shows the building in which the instruments are housed and inlets and samplers on the roof.

<u>Site location:</u>

- The site is adjacent to an ARB site in the same building in a business park and immediately adjacent to a shopping center and school.
- The site is only about 0.2 mile from one of the busiest intersections in Bakersfield (Stockdale & California) and within 30 ft of an operating oil rig.

<u>Climate:</u>

- The site elevation is almost at sea level in an arid environment with annual precipitation less than seven inches. The site is hot and dry in the summer with most annual precipitation occurring from November through March. The site is subject to summer temperatures often above 110°F and to some fog episodes in the fall through winter.

<u>Site construction and amenities:</u>

- The site is in a single-story office/industrial building. The site has an 8-ft false ceiling concealing a 5-ft gap to the true ceiling. All pump lines and associated control cables were extended through the ceiling tiles and back down into the pump closet. The pumps were installed in a separate room with an independent ventilation system. Access to the inlets and samplers contained on the roof is from the ARB site. A 4-ft lip surrounds the perimeter of the roof.

Major issues:

- Local Sources – These include an operating oil rig, exhaust from heaters on the roof near the inlets, and vehicle emissions. Heater-duct modifications were made before the Winter Study. These modifications raised the exhaust from 4 ft to 10 ft above the roofline.
- Analog Signals – Due to the building configuration, all analog signals were subject to varying degrees of electrical interference from local sources and were very noisy as a result. Interestingly, some digital signals were affected as well (e.g., NO_y).

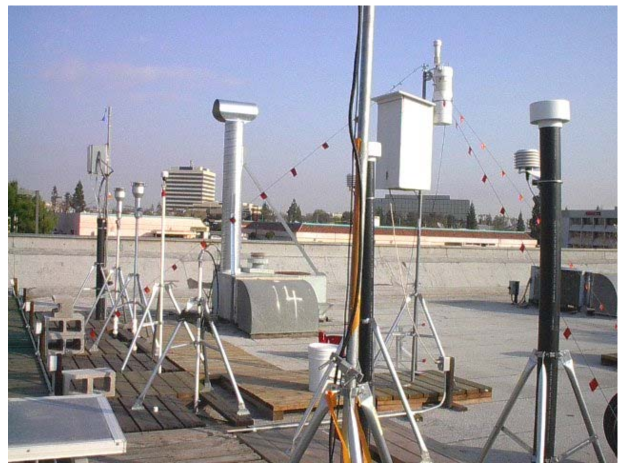


Figure 3-7. Photos of the Bakersfield (BAC) annual Anchor site. Left is outside of building; right shows inlets and samplers on roof.

3.4.2 Site Measurements

Figure 3-8 and **Table 3-4** detail the operation period of BAC annual Anchor site-instruments and samplers and the instruments and samplers operated at the BAC annual Anchor site.

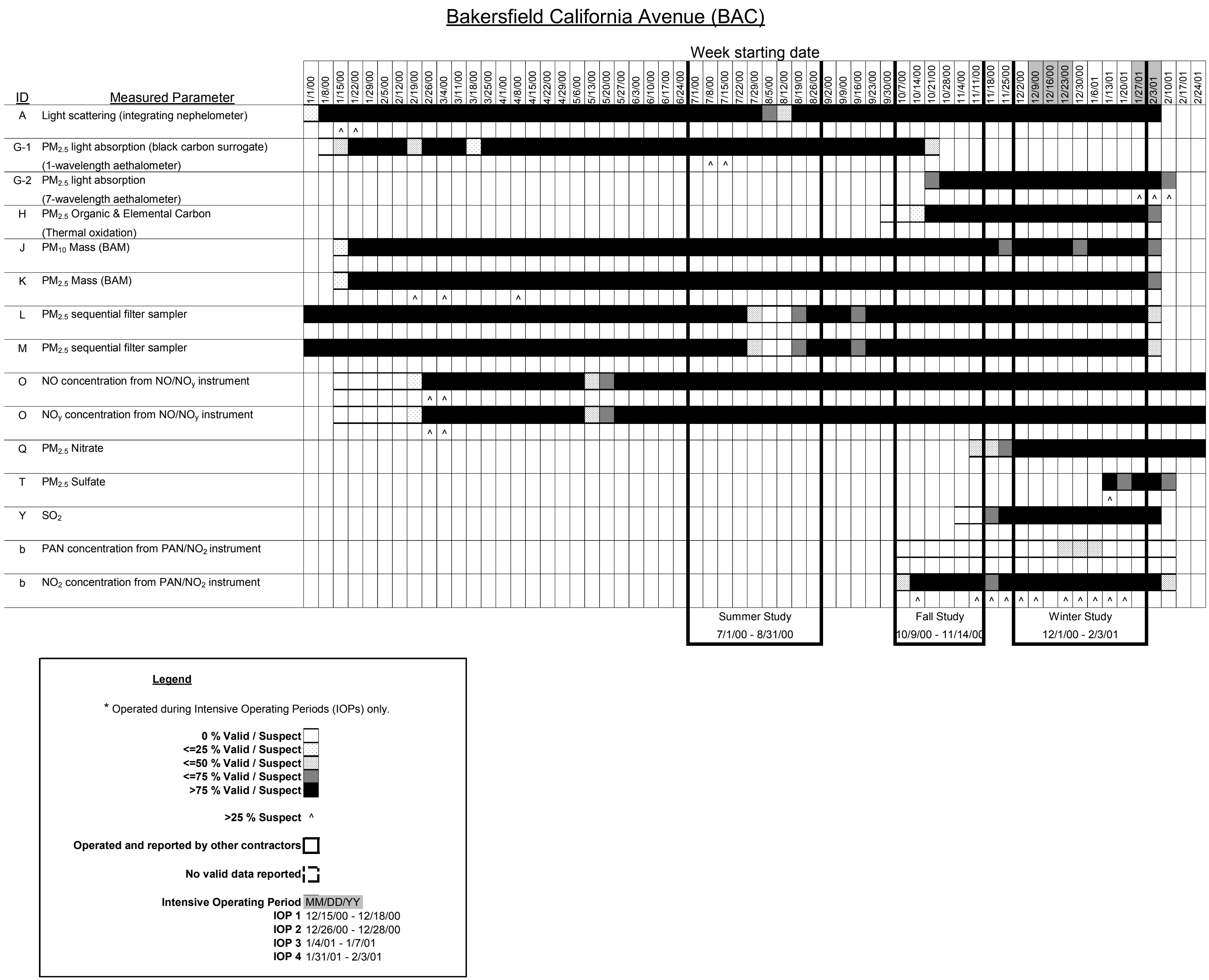


Figure 3-8. Operation period of BAC annual Anchor-site instruments and samplers.

Table 3-4. Instruments and samplers operated at the BAC annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS #2	010204	12/15/99	2/8/01
	Calibrator - Site cal	Environics	9100 Calibrator	2574	010128	1/11/00	2/8/01
	Zero air generator	Aadco	737R-11A Zero air generator	2652	010131	1/11/00	2/8/01
A	Light scattering	Radiance Research	M903 Nephelometer	0213	010143	1/10/00	10/18/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0194	010139	10/18/00	11/15/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0213	010143	11/15/00	2/6/01
G-1	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	231:23H5	010121	1/7/00	10/23/00
G-2*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	256:82U6	010249	10/23/00	2/6/01
H	$PM_{2.5}$ Organic and elemental carbon	Rupprecht & Patashnick	5400 OC/EC	5400 OC/ECC2 02860008	ARB 20005552	10/4/00	02/5/01
J	PM_{10} mass	Met One Instruments	1020 BAM	x4153	010112	1/19/00	2/6/01
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x5217	010116	1/22/00	02/06/01
L,M	SFS	DRI	SFS	3	DRI 605842	12/3/99	2/5/01
O	NO_y	Thermo Environmental Instruments	42C/Y Single converter	64749-345	010123	1/20/00	3/26/01
Q	Nitrate Generator	Rupprecht & Patashnick	8400N	840NA20 1210009	ARB	11/9/00	3/6/01
Q	$PM_{2.5}$ Nitrate Analyzer	Rupprecht & Patashnick	8400N	73	ARB	11/9/00	3/6/01
T	Sulfate Generator	Rupprecht & Patashnick	8400S	840SA20 1060011	010136	1/12/01	2/16/01
T	$PM_{2.5}$ Sulfate Analyzer	Rupprecht & Patashnick	8400S	59	010137	1/12/01	2/5/01
Y	SO_2	Thermo Environmental Instruments	43S	43S43487 269	STI	11/9/00	2/8/01
b	PAN/NO_2	CECERT	PAN/NO_2	08	010735	10/11/00	2/12/01

* The original instrument was replaced with this instrument.

3.5 BODEGA BAY (BODB) – WINTER ANCHOR SITE

3.5.1 Site Characteristics

Details of the Bodega Bay (BODB) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-9** shows the location of the Aethalometer and Aethalometer inlet.

Site location:

- The site is located in a naturally vegetated area and is approximately one-half mile from the Bay.
- The site is in a U.C. Davis research complex with no significant local sources or major roads.

Climate:

- The site is at sea level in a delta environment subject to local coastal influences of fog and precipitation. The site is subject to fog episodes throughout the year.

Site construction and amenities:

- The instruments were mounted in a greenhouse with no climate control although it had a thermostatically controlled ventilation fan.

Major issues:

- Water – There was frequent pooling of water on ground. It is unclear whether the water resulted from rain or sprinklers. A power strip was shorted on several occasions by falling into this water.
- Power – There were frequent blackouts.

Figure 3-9. Photos of Bodega Bay (BODB) winter Anchor site. Aethalometer is in front right side of greenhouse at left. Right shows Aethalometer inlet.

3.5.2 Site Measurements

Figure 3-10 and **Table 3-5** detail the operation period of BODB winter Anchor-site instruments and the instruments operated at the BODB winter Anchor site.

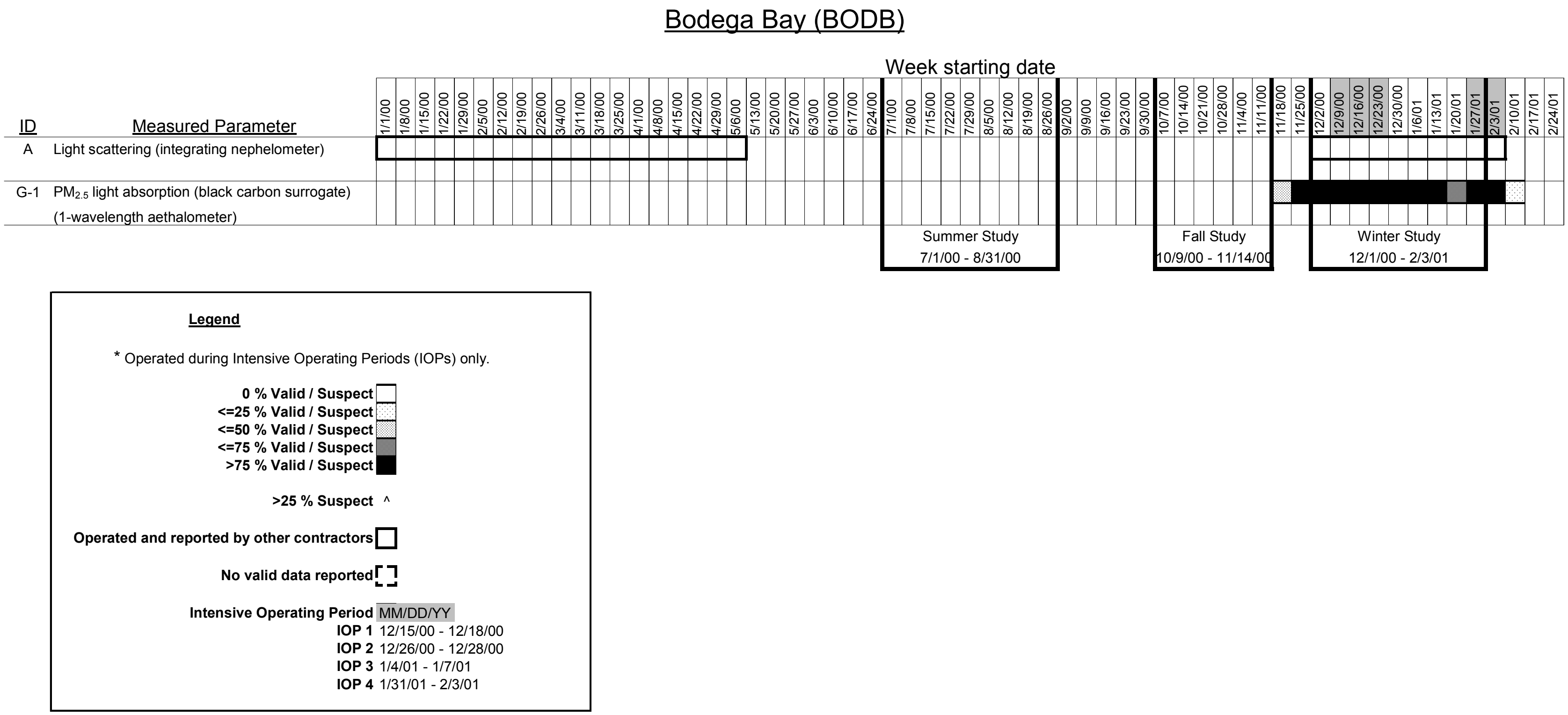


Figure 3-10. Operation period of BODB winter Anchor-site instruments.

Table 3-5. Instruments operated at the BODB winter Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS4	010205	11/21/00	2/15/01
A	Light scattering	Radiance Research	M903 Nephelometer	0194	010139	12/23/99	5/10/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0248	010251	12/4/00	2/04/01
G-1	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	228:25R6	010119	11/21/00	2/15/01

* The original instrument was replaced with this instrument.

3.6 BETHEL ISLAND (BTI) – WINTER ANCHOR SITE

3.6.1 Site Characteristics

Details of the Bethel Island (BTI) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-11** shows the ARB trailer and CRPAQS Anchor-site trailer.

Site location:

- The site is adjacent to a BAAQMD site in a self-storage facility. There is limited road access to the site. It is less than 0.2 mile from the slough separating the island from the mainland near Oakley.
- The site is in a rural area with some light agricultural activity and pasture adjacent to the site.

Climate:

- The site is at sea level in the delta environment subject to local fog and drizzle. The site is subject to summer temperatures often above 85°F and to fog episodes in the fall through winter. Winds are moderate from the west much of the time.

Site construction and amenities:

- The instruments were mounted inside a small temporary trailer with no false ceilings and no deck on the roof.
- The cylinders were mounted outside and the pumps were mounted underneath the trailer on pallets. Partway through the winter, the site operator insulated the cylinders. Skirting around the trailer base was installed in December.
- Access to the roof was via a ladder. The SFS sampler was installed on the adjacent BAAQMD trailer roof because it had a deck.

Major issues:

- Power – There were frequent blackouts due to inclement weather and frequent brownouts because the utility company was unable to add enough power to support the continuous instruments. There were additional problems during the IOPs due to increased electrical demand.
- Water – The trailer developed a number of leaks. During the winter, the trailer company repaired several of these leaks by using a tar-based fixative.

Figure 3-11. Photos of Bethel Island (BTI) winter Anchor site. Left is ARB trailer with roof deck; right is CRPAQS Anchor-site trailer.

3.6.2 Site Measurements

Figure 3-12 and **Table 3-6** detail the operation period of BTI winter Anchor-site instruments and samplers and the instruments and samplers operated at the BTI winter Anchor site.

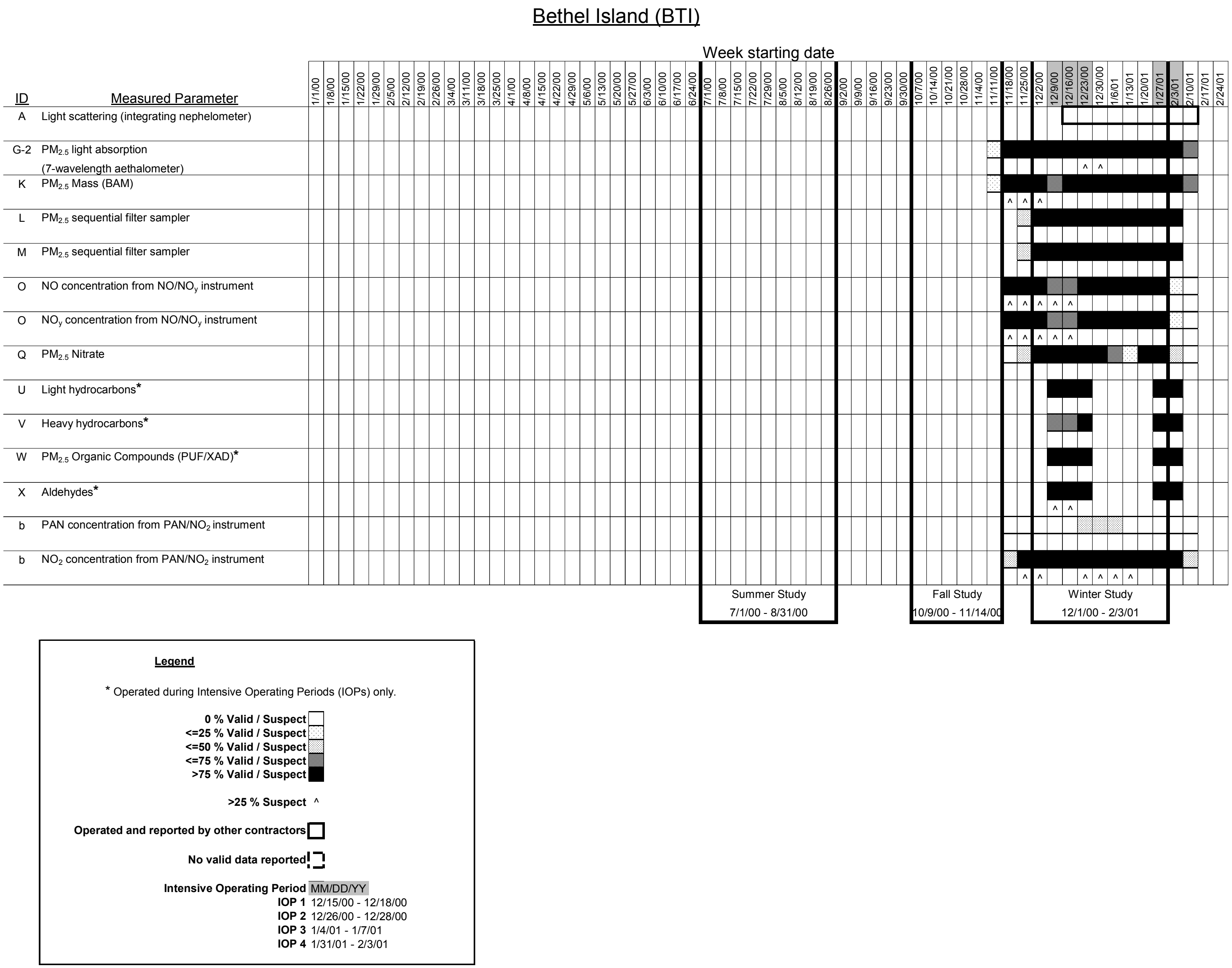


Figure 3-12. Operation period of BTI winter Anchor-site instruments and samplers.

Table 3-6. Instruments and samplers operated at the BTI winter Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS10	010639	11/15/00	2/11/01
	Calibrator - Site cal	Environics	9100 Calibrator	E2662	010386	11/23/00	2/11/01
	Zero air generator	Aadco	737R-11A Zero air generator	2669	010406	11/23/00	2/11/01
A	Light scattering	Radiance Research	M903 Nephelometer	0301	010644	12/18/00	2/11/01
G-2	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	255:84E7	010642	11/17/00	2/15/01
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y2133	010621	11/19/00	12/8/00
K*	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	x4946	010117	12/8/00	2/06/01
L, M	SFS	DRI	SFS	10-01	DRI	11/20/00	2/06/01
O	NO_y	Thermo Environmental Instruments	42C/Y Single converter	66395-352	010373	11/22/00	2/11/01
Q	$PM_{2.5}$ Nitrate Generator	Rupprecht & Patashnick	8400N	840NA2010 70006	010640	11/21/00	1/18/01
Q	$PM_{2.5}$ Nitrate Analyzer	Rupprecht & Patashnick	8400N	55	010641	11/21/00	2/11/01
Q*	$PM_{2.5}$ Nitrate Generator	Rupprecht & Patashnick	8400N	840NA2010 40006	Rupprecht & Patashnick	1/18/01	2/11/01
U	Light hydrocarbons	OGI	Canister	?	Rasmussen	11/20/00	2/06/01
V	Heavy hydrocarbons	DRI	Tenax	6-14/8	DRI 604522	11/20/00	2/06/01
W	$PM_{2.5}$ organics	DRI	PUF/XAD	B14	DRI	11/20/00	2/06/01
X	Carbonyl Sampler	ATMAA	Sampler	27/28	AtmAA	11/21/00	2/06/01
b	PAN/NO_2	CECERT	PAN/NO_2	05	010732	11/22/00	2/11/01

* The original instrument was replaced with this instrument.

3.7 CORCORAN PATTERSON AVENUE (COP) – FALL ANCHOR SITE

3.7.1 Site Characteristics

Details of the Corcoran Patterson Avenue (COP) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-13** shows the COP fall Anchor-site structure.

Site location:

- The site is located in a school bus parking and maintenance area.
- The site is adjacent to a school in a residential area with railroad tracks and mixed-agriculture and dairy operations located within one-half mile.

Climate:

- The site is almost at sea level in an arid environment with annual precipitation less than nine inches. It is hot and dry in the summer with temperatures often above 110°F, and subject to some fog episodes in the fall through winter.

Site construction and amenities:

- The instruments were mounted in a small shared temporary trailer with no false ceiling and minimal temperature control with a deck on the roof.

Major issues:

- Local Sources – Possible local sources include diesel school-bus exhaust, blowing dust and dirt from the shredded rubber used in the parking area, nearby agricultural activity, and trains.

Figure 3-13. Photos of Corcoran (COP) fall Anchor site.

3.7.2 Site Measurements

Figure 3-14 and **Table 3-7** detail the operation period of COP fall Anchor-site instruments and the instruments operated at the COP fall Anchor site.

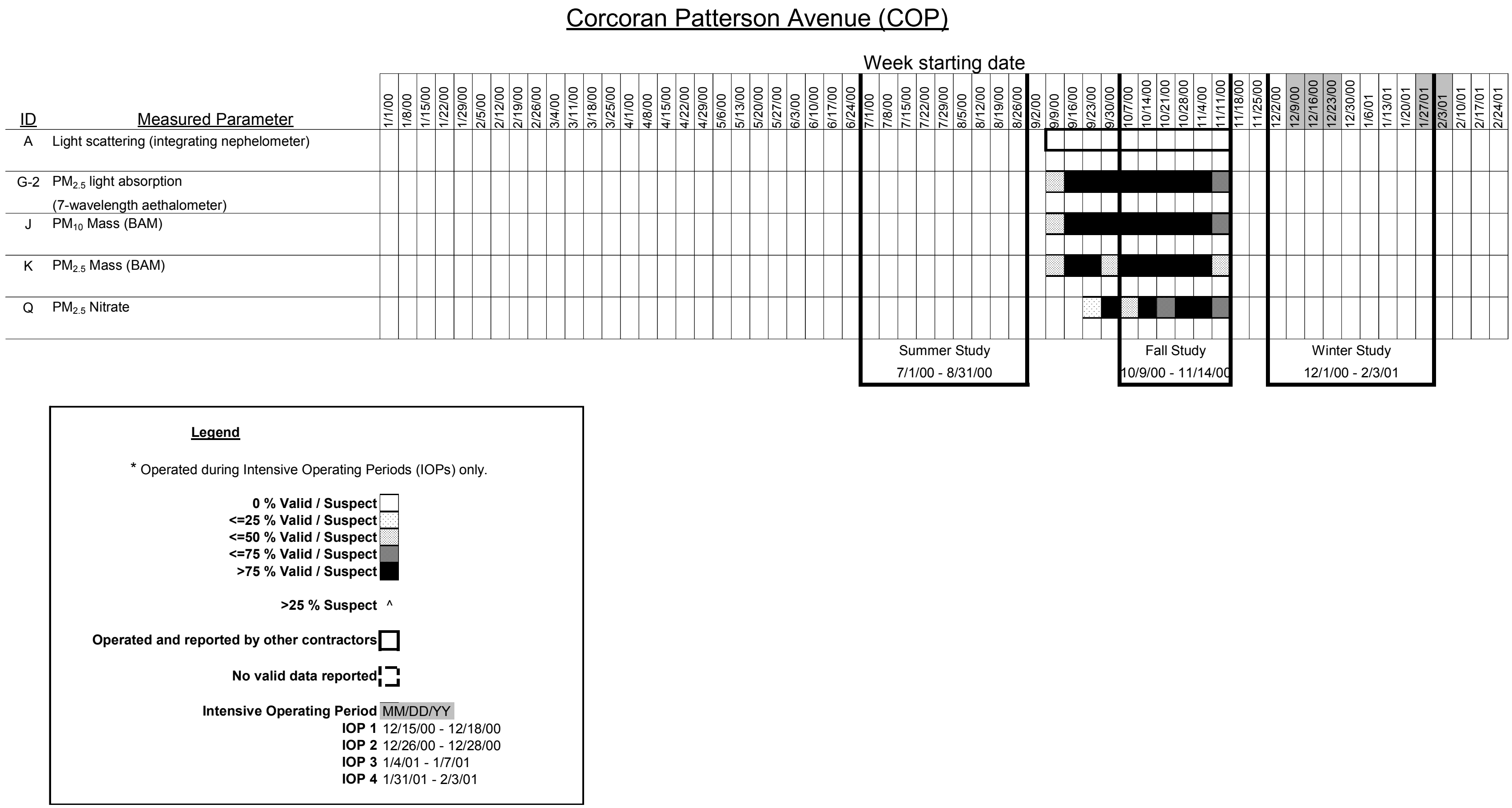


Figure 3-14. Operation period of COP fall Anchor site instruments.

Table 3-7. Instruments operated at the COP fall Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA Prop Tag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS4	010205	9/13/00	11/15/00
A	Light scattering	Radiance Research	M903 Nephelometer	0274	010302	9/13/00	11/15/00
G-2	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	271:37B0	010173	9/13/00	11/15/00
J	PM_{10} mass	Met One Instruments	1020 BAM	y2134	010624	9/13/00	11/15/00
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y2133	010621	9/13/00	11/15/00
Q	Nitrate Generator	Rupprecht & Patashnick	8400N	840NA201 060006	NA	9/29/00	10/26/00
Q*	Nitrate Generator	Rupprecht & Patashnick	8400N	840NA201 070006	010626	10/26/00	11/15/00
Q	$PM_{2.5}$ Nitrate Analyzer	Rupprecht & Patashnick	8400N	58	010627	9/29/00	11/15/00

* The original instrument was replaced with this instrument.

3.8 EDWARDS AIR FORCE BASE (EDW) – SUMMER ANCHOR SITE

3.8.1 Site Characteristics

Details of the Edwards Air Force Base (EDW) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-15** shows the EDW summer Anchor-site structure.

Site location:

- The site is located in an existing air-quality station on Edwards Air Force Base adjacent to a planetarium. The existing site was maintained by Xontec under contact to Edwards Air Force Base.
- It is in a remote desert location with aircraft testing and training areas one-half mile from the site.

Climate:

- The site is located in the western Mojave Desert. High July and August temperatures, often above 115°F, combined with strong gusty winds made servicing of the instruments a challenge at times. The site is also subject to flashfloods and dust-storms.

Site construction and amenities:

- The instruments were mounted in a trailer with no false ceiling and with a deck. Pumps were installed on pallets outside of the trailer. They were covered with boxes with minimal ventilation.

Major issues:

- Access – Site access had to be prearranged, hampering quick response time to fix instrument problems. Personnel could not drive directly to trailer; equipment had to be hand-carried to site.
- Phone – There was no dedicated-line phone access to the site. The existing phone line was shared with Xontec. There were frequent problems with the DAS phone connection being unplugged.
- Power – Sufficient power was provided. However, there were frequent power interruptions to the data system (most likely unplugged by Xontec).
- Local sources – Much of the area surrounding the site was not vegetated and dusty and subject to very windy conditions most of the time, which resulted in wind-blown dust. The instruments required more frequent maintenance as a result.

Figure 3-15. Edwards (EDW) summer Anchor site.

3.8.2 Site Measurements

Figure 3-16 and **Table 3-8** detail the operation period of EDW summer Anchor-site instruments and the instruments operated at the EDW summer Anchor site.

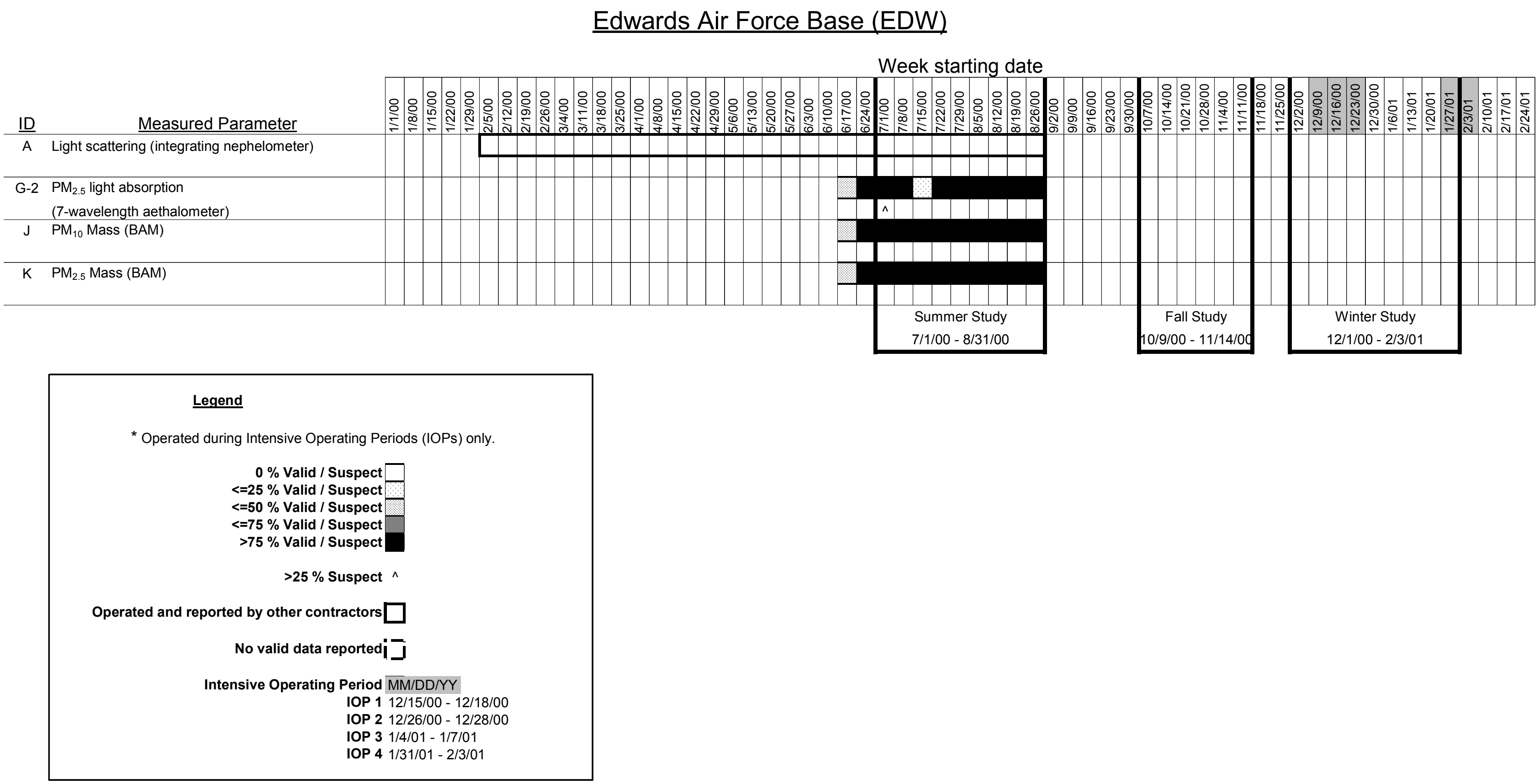


Figure 3-16. Operation period of EDW summer Anchor-site instruments.

Table 3-8. Instruments operated at the EDW summer Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA PropTag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS4	010206	6/20/00	9/01/00
A	Light scattering	Radiance Research	M903 Nephelometer	0235	010153	2/8/00	9/01/00
G-2	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	256:82U6	010249	6/20/00	9/01/00
J	PM_{10} mass	Met One Instruments	1020 BAM	y2134	010624	6/20/00	9/01/00
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y2133	010621	6/20/00	9/01/00

3.9 MODESTO 14TH STREET (M14) – WINTER ANCHOR SITE

3.9.1 Site Characteristics

Details of the Modesto 14th Street (M14) site's physical features—location, climate, and construction—and issues related to the site follow. **Figure 3-17** shows the M14 winter Anchor-site facility.

Site location:

- The site was in a downtown area at an existing ARB site.

Climate:

- The site elevation is almost at sea level in an arid environment with annual precipitation less than nine inches. It is hot and dry in the summer with most annual precipitation occurring from November through March. It is often subject to summer temperatures above 100°F and to fog episodes in the fall through winter.

Site construction:

- The site is in a business park with false ceilings. The roof height was inconsistent across the building. As a result, there were many obstacles for flow around the inlets. The site was climate-controlled. Pumps were installed inside.

Major issues:

The inconsistent roof height and obstacles on the roof may have affected flow to the $PM_{2.5}$ Black Carbon (Aethalometer) sample inlet.

Figure 3-17. Photos of Modesto (M14) winter Anchor site.

3.9.2 Site Measurement

Figure 3-18 and **Table 3-9** detail the operation period of M14 winter Anchor-site instruments and the instruments operated at the M14 winter Anchor site.

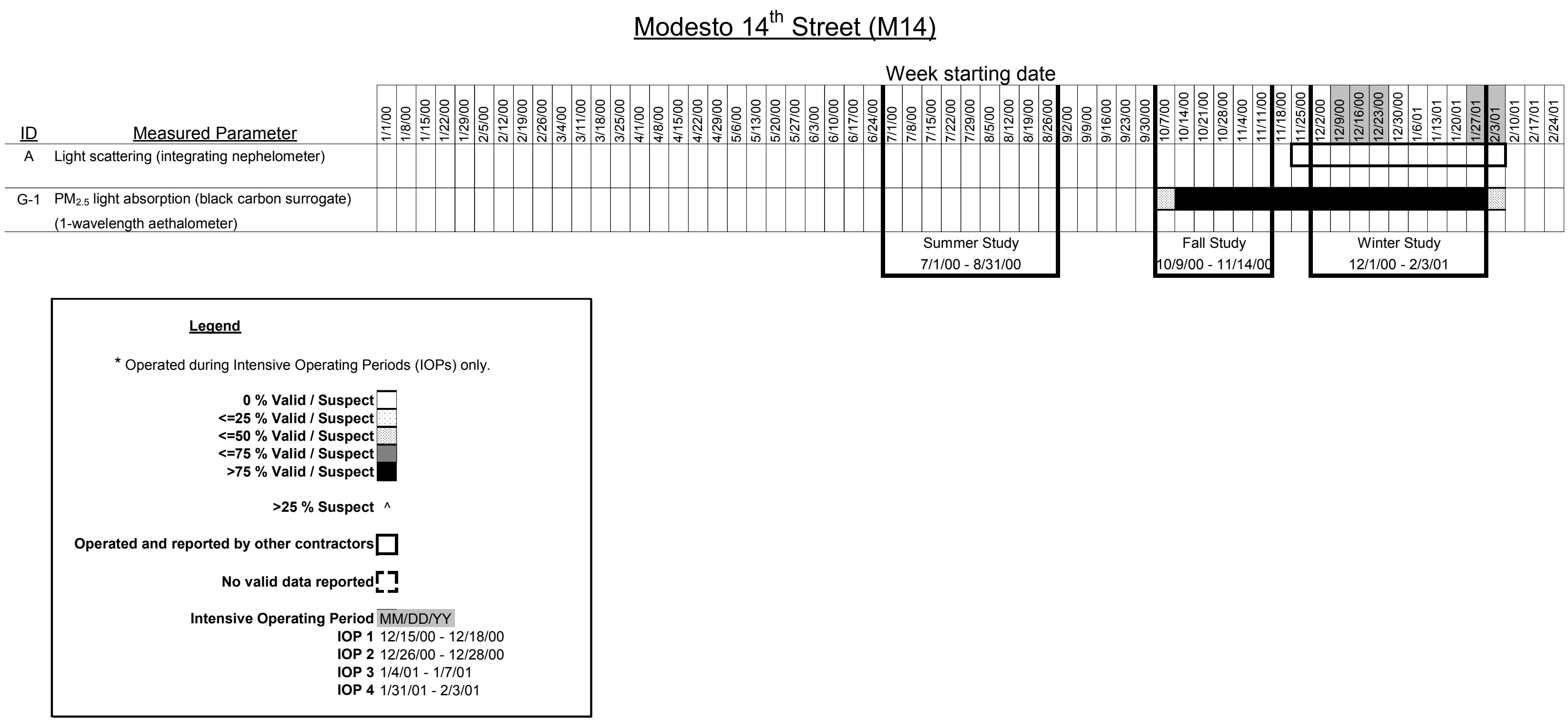


Figure 3-18. Operation period of M14 winter Anchor-site instruments.

Table 3-9. Instruments operated at the M14 winter Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA PropTag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS7	010631	10/10/00	2/06/01
A	Light scattering	Radiance Research	M903 Nephelometer	0301	010644	12/1/00	2/06/01
G-1	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	225:87T2	010118	10/10/00	2/06/01

3.10 SACRAMENTO DEL PASO MANOR (SDP) – ANNUAL ANCHOR SITE

3.10.1 Site Characteristics

Details of the Sacramento Del Paso Manor (SDP) site's physical features—location, climate, construction, and amenities—and issues related to the site follow. **Figure 3-19** shows the SDP annual Anchor-site facility.

Site location:

- The site is located in a schoolyard in a residential area.
- The site is collocated with a SMAQMD meteorological and air-quality monitoring site adjacent to a city-maintained well and pump-station.

Climate:

- The site elevation almost at sea level. There is some delta influence with annual precipitation less than 15 inches. The area is hot and can be humid in the summer with most annual precipitation occurring in November through March. The site is subject to summer temperatures often above 100°F and to fog episodes in the fall through winter.

Site construction and amenities:

- The instruments were mounted in a permanent trailer with a metal deck on top and no false ceiling. Pumps were installed inside. The trailer was climate-controlled using the trailer thermostat.

Major issues:

- Limited space – The CRPAQS instruments had to be installed behind a rack and were awkward to service.
- Power – Frequent blackouts and brownouts occurred due to limited power supply and inclement weather.

Figure 3-19. Photo of Sacramento Del Paso (SDP) annual Anchor site.

3.10.2 Site Measurement

Figure 3-20 and **Table 3-10** detail the operation period of SDP annual Anchor site instruments and the instruments operated at the SDP annual Anchor site.

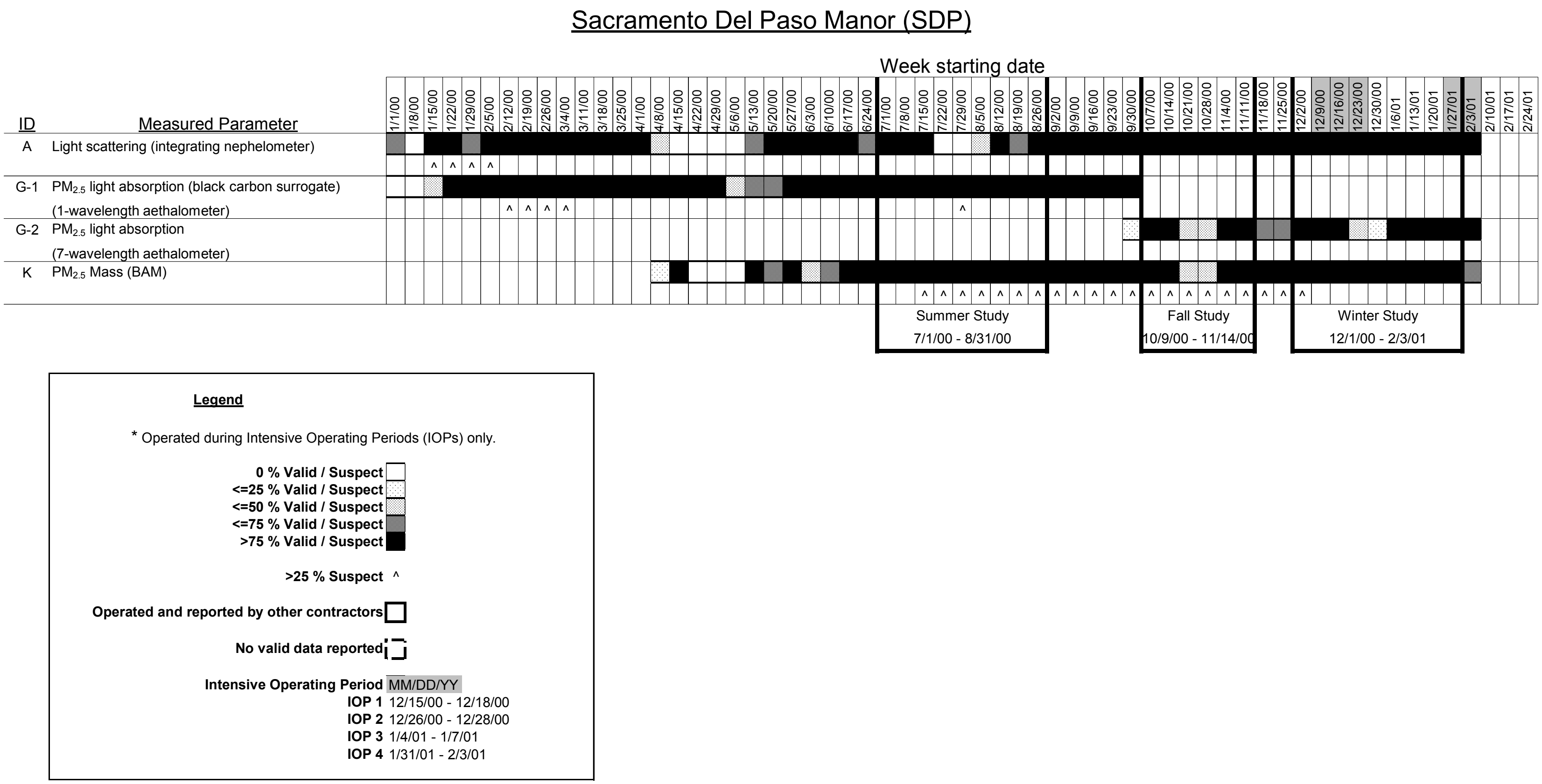


Figure 3-20. Operation period of SDP annual Anchor-site instruments.

Table 3-10. Instruments operated at the SDP annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA PropTag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS4	010206	12/6/99	5/13/00
*	DAS	Immecore	NA	CRPAQS9	010202	5/13/00	2/07/01
A	Light scattering	Radiance Research	M903 Nephelometer	0212	010142	12/24/99	5/13/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0264	010257	5/13/00	6/14/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0212	010142	6/14/00	8/7/00
A*	Light scattering	Radiance Research	M903 Nephelometer	0293	010280	8/8/00	2/07/01
G-1	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	229:32U2	010120	12/6/99	10/6/00
G-2*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	272:30O2	010662	10/6/00	12/5/00
G-2*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	271:37B0	010173	12/5/00	2/07/01
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y1484	SACQMD 00266	4/13/00	2/07/01

* The original instrument was replaced with this instrument.

3.11 SAN JOSE 4TH STREET (SJ4) – ANNUAL ANCHOR SITE

3.11.1 Site Characteristics

Details of the San Jose 4th Street (SJ4) site's physical features—location, climate, and construction—and issues related to the site follow. **Figure 3-21** shows the SJ4 annual Anchor-site facility.

Site location

- The site is located in a downtown business park at existing BAAQMD site.
- It is in close proximity to 4th Street with heavy commuter traffic at peak hours.

Climate:

- The site is almost at sea level and about 11 miles downwind (SE) of the San Francisco Bay. It has with precipitation greater than 20 inches. The site is warm in the summer with most annual precipitation occurring from November through March. Summer temperatures are often above 90°F, and the site experiences fog episodes in the summer through winter.

Site construction:

- Instruments were mounted in an older building in a business park with false ceilings.
- Pumps were installed on the roof.
- All cylinders were installed inside the site.
- The site was climate-controlled.

Major issues:

- Space – Due to limited space and roof access holes, instrument installations were awkward and spread out over several rooms.
- Local sources – The site is in close proximity to the street with commuter traffic heavy at peak hours and local manufacturing and industrial sources within one mile of the site. The nearby emissions sources caused frequent servicing of instruments to be required.

Figure 3-21. Photos of San Jose (SJ4) annual Anchor site.

3.11.2 Site Measurements

Figure 3-22 and **Table 3-11** detail the operation period of SJ4 annual Anchor-site instruments and the instruments operated at the SJ4 annual Anchor site.

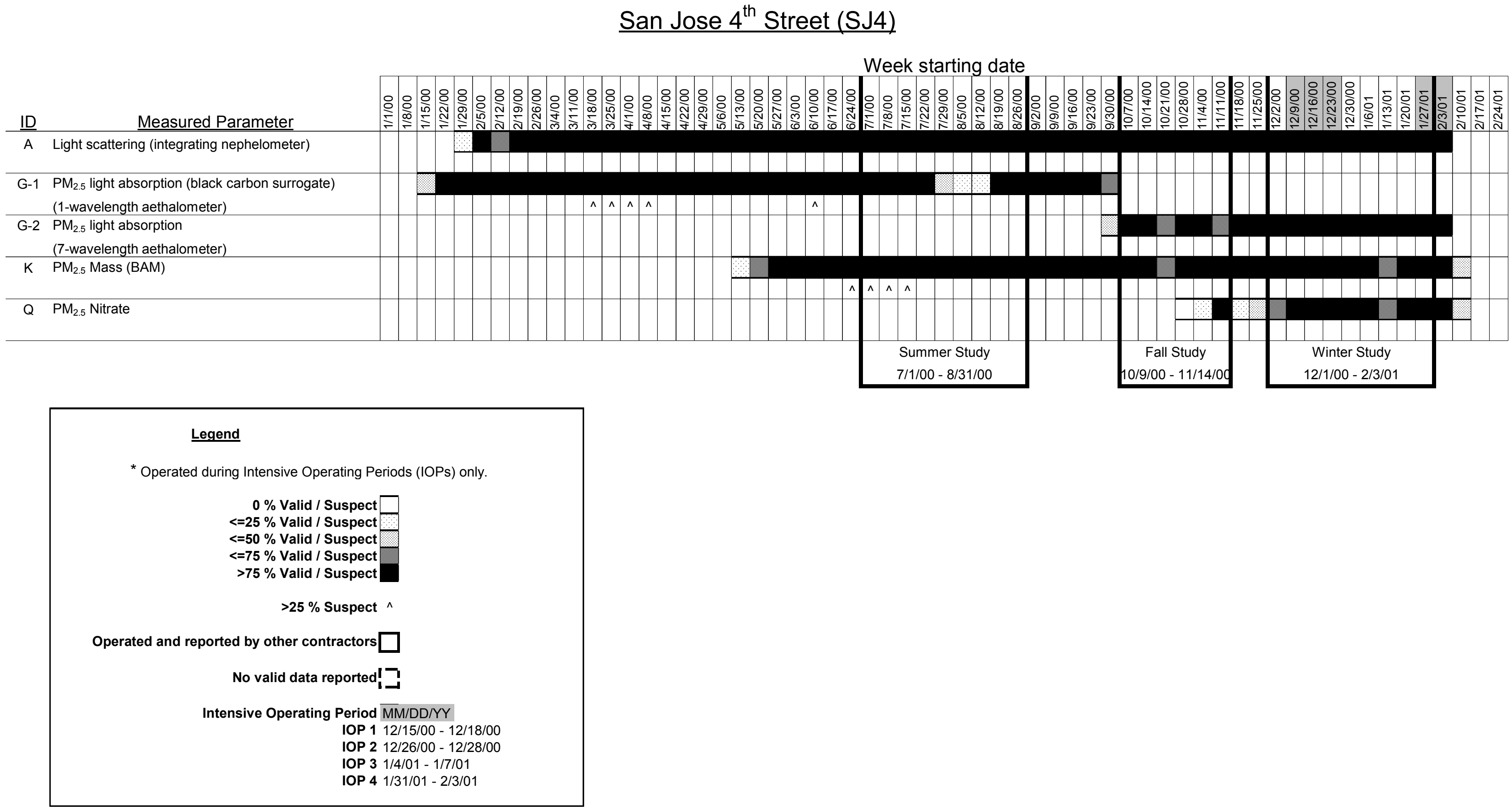


Figure 3-22. Operation period of SJ4 annual Anchor-site instruments.

Table 3-11. Instruments operated at the SJ4 annual Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA PropTag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS5	010203	2/3/00	2/08/01
A	Light scattering	Radiance Research	M903 Nephelometer	0228	010146	2/3/00	2/08/01
G-1	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	233:25J4	010118	1/20/00	4/10/00
G-1*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	225:87T2	010118	4/10/00	5/17/00
G-1*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	233:25J4	010122	5/17/00	8/10/00
G-1*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE1X Aethalometer	225:87T2	010118	8/10/00	10/4/00
G-2*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	273:29N2	010634	10/4/00	2/08/01
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y1722	BAAQMD	5/18/00	2/15/01
Q	Nitrate Generator	Rupprecht & Patashnick	8400N	840NA20 1030004	010635	11/2/00	2/15/01
Q	$PM_{2.5}$ Nitrate Analyzer	Rupprecht & Patashnick	8400N	59	010636	11/2/00	2/15/01

* The original instrument was replaced with this instrument.

3.12 SIERRA NEVADA FOOTHILLS (SNFH) – WINTER ANCHOR SITE

3.12.1 Site Characteristics

Details of Sierra Nevada Foothills (SNFH) site's physical features—location, climate, and construction—and issues related to the site follow. **Figure 3-23** shows the SNFH winter Anchor-site trailer.

Site location:

- The site was located in a remote rural area in the Sierra Nevada foothills at an elevation of 589 msl between Auberry and Prather.
- The site was adjacent to and east of Swiss Dane Corporation which had an operational painting plant and adjacent to and north of a resident who routinely incinerated trash.

Climate:

- The site is in a Sierra foothill environment with annual precipitation greater than 20 inches some of which is snowfall accumulation. The site was subject to fog episodes in the fall through winter, although it was often situated at or just above the Central Valley fog and haze tops.

Site construction:

- Instruments were mounted inside a temporary trailer with no false ceilings and with a deck above for the inlets and SFS and SGS samplers.
- The pumps were mounted below the trailer on pallets with boxes covering them. The trailer was skirted so ventilation under the trailer was minimal.
- All gas cylinders were installed inside the trailer.

Major issues:

- Local sources – Up until his death, a resident to the east had a bonfire every day for approximately three hours starting at about 1500 PST. The signature from the bonfire was seen in the data (especially NO_y). Another local source was the Swiss Dane Corp. A clear influence of the painting processes was not seen in the data, but painting times were recorded for future data analysis.

Figure 3-23. Photo of Sierra Nevada Foothills (SNFH) winter Anchor site.

3.12.2 Site Measurements

Figure 3-24 and **Table 3-12** detail the operation period of SNFH winter Anchor-site instruments and samplers and the instruments and samplers operated at the SNFH winter Anchor site.

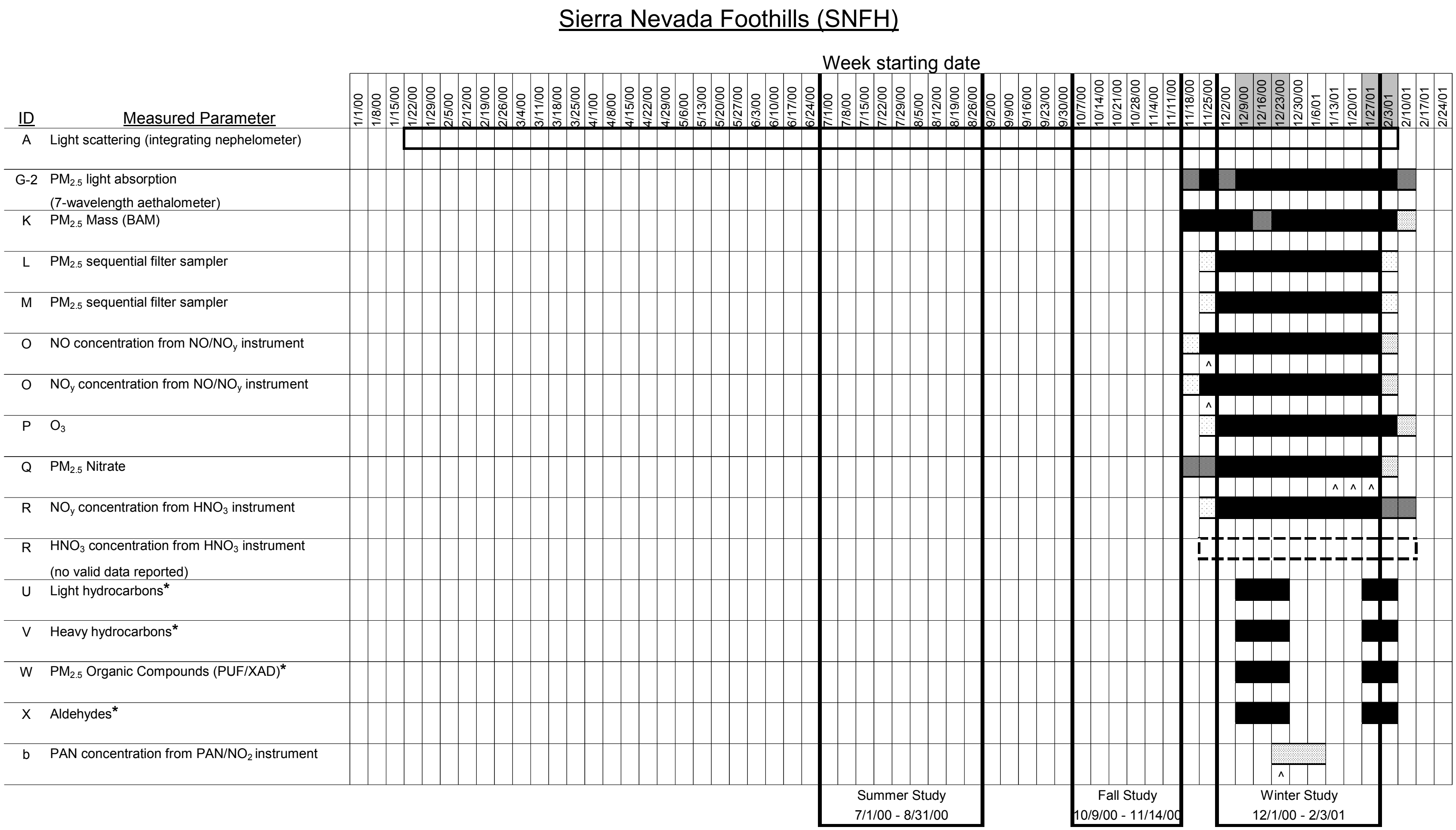


Figure 3-24a. Operation period of SNFH winter Anchor site-instruments and samplers (page 1).

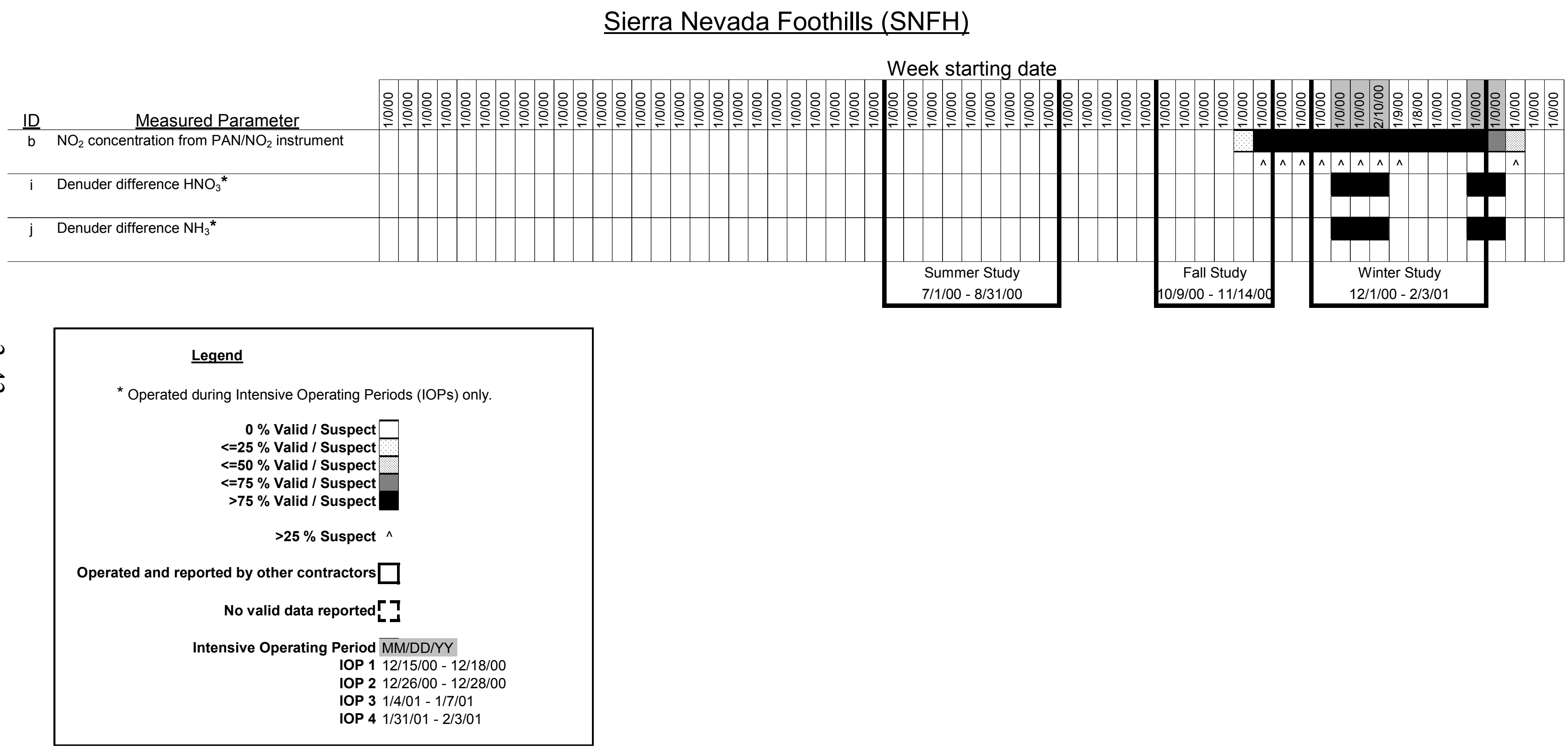


Figure 3-24a. Operation period of SNFH winter Anchor site-instruments and samplers (page 2).

Table 3-12. Instruments and samplers operated at the SNFH winter Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA PropTag	On-line Date	Off-line Date
	DAS	Immecore	NA	CRPAQS1	010633	11/2/00	2/13/01
	Calibrator - Site cal	Environics	9100 Calibrator	E2663	010395	11/9/00	2/13/01
	Zero air generator	Aadco	737R-11A Zero air generator	2668	010396	11/9/00	2/13/01
A	Light scattering	Radiance Research	M903 Nephelometer	0227	010145	1/22/00	2/08/01
G-2	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	271:37B0	010173	11/18/00	12/6/00
G-2*	$PM_{2.5}$ Black carbon	Andersen Instruments	AE3X Aethalometer	272:30O2	010662	12/6/00	2/13/01
K	$PM_{2.5}$ mass	Met One Instruments	1020 BAM	y2134	010624	11/20/00	2/8/01
L,M	SFS	DRI	SFS	605846	DRI	11/30/00	2/06/01
O	NO_y	Thermo Environmental Instruments	42C/Y Single converter	66470-352	010352	11/30/00	2/13/01
P	O_3	Advanced Pollution Instruments	400A	375	010421	11/20/00	12/1/00
P*	O_3	Advanced Pollution Instruments	400A	373	010366	12/1/00	2/13/01
Q	Nitrate Generator	Rupprecht & Patashnick	8400N	840NA2010 60006	010626	11/19/00	2/06/01
Q	$PM_{2.5}$ Nitrate Analyzer	Rupprecht & Patashnick	8400N	58	010627	11/19/00	2/06/01
R	HNO_3	Thermo Environmental Instruments	42C/Y Dual converter	67178-355	010436	11/30/00	2/13/01
U	Light hydrocarbons	OGI	Canister	2	Rasmussen	12/1/00	2/06/01
V	Heavy hydrocarbons	DRI (2 Samplers)	Tenax	6X13, UNIT 1	DRI	11/19/00	2/06/01
W	$PM_{2.5}$ organics	DRI	PUF/XAD	3	DRI	11/19/00	2/06/01
X	Carbonyl Sampler	ATMAA	Sampler	26	ATMAA	11/21/00	2/06/01
b	PAN/NO_2	CECERT	PAN/NO_2	06	010733	11/30/00	12/19/00
b*	PAN/NO_2	CECERT	PAN/NO_2	04	010731	12/19/00	2/13/01
f	SGS	DRI	NA	SGS-001	DRI	11/30/00	2/06/01
g	SGS	DRI	NA	605836	DRI	11/30/00	2/06/01

* The original instrument was replaced with this instrument.

3.13 WALNUT GROVE (WAG, WGT) – WINTER ANCHOR SITE

3.13.1 Site Characteristics

Details of the Walnut Grove (WAG, WGT) site's physical features—location, climate, and construction—and issues related to the site follow. **Figure 3-25** shows the winter Anchor-site layout and CRPAQS enclosures.

Site location:

- The site is located on the 600-m (2000-ft) KCRA tower in Walnut Grove and surrounded by agricultural fields with minimal road access up to site. Instruments were located at 10 m and 245 m msl.

Climate:

- The site is at sea level. Delta influence with annual precipitation greater than 20 inches. Site subject to delta and regional fog episodes in the fall through winter.

Site construction:

- Rack enclosures were installed on the lower catwalk (10 m) and on the 245-m catwalk. The instruments, pumps, and inlets were installed in these enclosures.
- All gas cylinders were secured to the catwalk immediately adjacent to the enclosures.
- Temperature control was achieved using a cooling temperature switch that would activate the fan when the temperature exceeded 72°F.

Major issues:

- Access to site – Access to the 245-m enclosure was limited by intermittent power interruptions to the elevator and inclement weather. This affected the frequency of maintenance performed on the instruments.
- Instrument installations – Instrument inlets were installed in an atypical fashion because of the limited space of the enclosures. The nitrate instrument used a side inlet with a split for transport flow. The temperature probe was mounted over 5 ft from the actual inlet and on the opposite side of the enclosure. The Aethalometer inlet had several 90° bends in order to accommodate the limited internal area of the enclosure.

Figure 3-25. Photos of Walnut Grove Tower (WAG/WGT) winter Anchor site. Top photos are from McDade (2002) showing the site layout. Lower left shows the CRPAQS enclosure on the catwalk at 10 m msl; lower right shows the CRPAQS enclosure at the 245 m msl level of the tower.

3.13.2 Site Measurements

Figure 3-26 and **Table 3-13** detail the operation period of WAG/WGT winter Anchor-site instruments and the instruments operated at the WAG/WGT winter Anchor site.

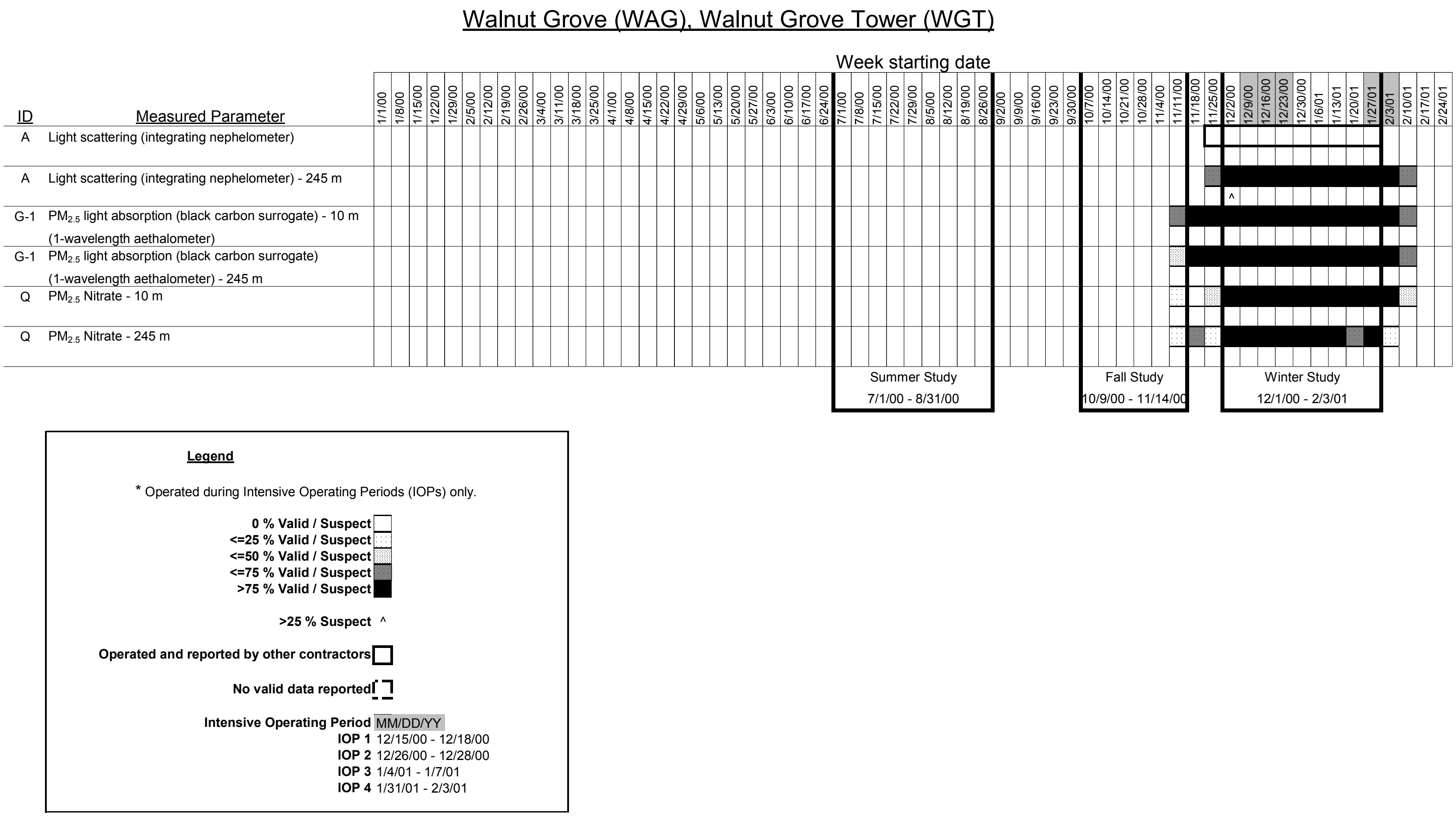


Figure 3-26. Operation period of WAG/WGT winter Anchor-site instruments.

Table 3-13. Instruments operated at the WAG/WGT winter Anchor site.

ID	Instrument	Instrument Vendor	Instrument Model	Vendor Serial	SJVAPSA PropTag	On-line Date	Off-line Date
	DAS - 10m	Immecore	NA	STI	NA	11/13/00	2/04/01
	DAS - 245m	Immecore	NA	STI	NA	11/14/00	2/04/01
A	Light scattering - 10m	Radiance Research	M903 Nephelometer	0291	010292	11/30/00	2/02/01
A	Light scattering - 245m	Radiance Research	M903 Nephelometer	0278	010318	11/26/00	12/15/00
A*	Light scattering - 245m	Radiance Research	M903 Nephelometer	0276	010318	12/15/00	2/13/01
G-1	$PM_{2.5}$ Black carbon - 10m	Andersen Instruments	AE1X Aethalometer	233:25J4	010122	11/13/00	2/13/01
G-1	$PM_{2.5}$ Black carbon - 245m	Andersen Instruments	AE1X Aethalometer	231:23H5	010121	11/14/00	2/13/01
Q	Nitrate Generator - 10m	Rupprecht & Patashnick	8400N	840NA20 1220009	ARB	11/26/00	2/13/01
Q	$PM_{2.5}$ Nitrate Analyzer - 10m	Rupprecht & Patashnick	8400N	68	ARB	11/26/00	2/13/01
Q	Nitrate Generator - 245m	Rupprecht & Patashnick	8400N	840NA20 1250009	ARB	11/16/00	2/06/01
Q	$PM_{2.5}$ Nitrate Analyzer - 245m	Rupprecht & Patashnick	8400N	70	ARB	11/16/00	2/06/01

* The original instrument was replaced with this instrument.

4. OPERATIONS AT THE CRPAQS ANCHOR SITES

This section of the field report describes our approach to field operations. The philosophy of operations described in Section 4.1 served as the foundation of the operations described in the rest of this section. The CRPAQS Anchor-site operations involve many participants, including the on-site operators, field management and support personnel, and STI office and data management staff. The roles and interactions of the participants are summarized in Section 4.2. Field operations were performed according to prescribed protocols and schedules. The field protocols, schedules, and documentation are outlined in Section 4.3

4.1 PHILOSOPHY OF OPERATIONS

The STI field operation philosophy requires clear instrument and site operational procedures, preventive maintenance, frequent performance evaluation of instrumentation to detect problems quickly and minimize data loss, and thorough documentation of field activities so that changes in instrument performance can be accounted for during data processing.

Changes to instrument settings were minimized to enable clearer tracking of instrument performance over time and to increase confidence that changes in instrument performance were real and not artifacts of problems with a calibration system.

Instrument performance was tested automatically using preprogrammed calibration methods and monitored manually by the site operator by following a prescheduled set of performance evaluation procedures and frequent calibration checks using external standards (when available). The most extensive checks and calibrations were performed at installation, on a quarterly basis, and at decommissioning.

Instrument performance was also monitored off-site by the field manager and a knowledgeable person at the STI main office on an (almost) daily basis. Both individuals received daily transmissions of the data and reviewed instrument issues with the site operator either in person or through telephone contact.

4.2 ROLES AND INTERACTIONS OF FIELD PARTICIPANTS

The success of the CRPAQS field effort depended on the activities and interactions of several levels of operational personnel. Complementary activities at the Anchor sites, at the field headquarters, and at STI provided a means to monitor the performance of the instruments and staff and to detect and remedy problems as quickly as possible.

These activities included automated operations performed at the sites (data logging, calibrations, and data transmission) and at STI (data polling, plotting, and posting to an STI web site for access by the field staff). Field operations included on-site instrument operation, checks, data reviews, documentation, and sample shipping. Operations at STI included data reviews and overall management and support activities. The field operations were directed and monitored by the field operations manager. The activities of the field participants are outlined below.

4.2.1 Automated Operations

- At each Anchor site, the STI DAS acquired data from all continuous instruments. The DAS was set up to receive data from asynchronous serial systems, to poll other digital systems when necessary, and to continuously record one-minute average data for all analog instruments. The DAS also controlled periodic zero and span activities that occurred nightly or in some cases four to six times per day. Most data were recorded on the DAS on a one-minute to one-hour basis. The nephelometer data were generally recorded internally on the instrument and transferred automatically to the DAS on a nightly basis.
- The STI data-center server system automatically called the on-site DAS nightly and uploaded data and calibration information to STI CRPAQS database. The systems were set up to upload the prior three days of data, so that if a day (or weekend) of data were somehow missed, it would be collected on the next upload cycle.
- The data-center system processed the uploaded data to engineering units and prepared time-series plots for review by STI analysts. Hard copies of the plots were displayed on a wall in the data center for review, and copies of the plots were also uploaded to a project web site for access by project personnel.

4.2.2 Field Technician Operations

The field technician site activities included the following tasks:

- Perform routine daily operational checks and maintenance in accordance with SOPs to ensure that the instruments were operating as well as possible (minimize off-line time due to instrument failure or malfunction);
- Perform periodic (e.g., weekly, monthly, etc.) calibrations and maintenance in accordance with SOPs so that the performance of the instruments is well-characterized over time and no settings were changed;
- Work with the field manager to troubleshoot instrument malfunctions or failures;
- Document operational checks, maintenance, and calibrations performed on instruments using worksheets and instrument log books;
- Summarize performance of instruments, any checks and maintenance performed on instrument, and off-line times using the site logbook on daily basis, and
- Change substrates and canisters in samplers, document all samples on chain of custody forms, and ship samples and documentation to the appropriate labs with copies archived on site and sent to STI.

4.2.3 STI Operations

The STI field support staff activities included performing the following daily tasks:

- Confirm that all data were uploaded and manually retrieve any data that were not transmitted automatically;

- Review uploaded data for unusual data and for proper operation of the instruments;
- Contact site operators and field manager when operational issues were identified; and
- Review chain of custody forms, summarize collected samples, and follow up on problems.

4.2.4 STI Field Manager and Support Staff

The STI Field Manager directed and monitored the activities of field personnel. In addition, the Field Manager's office provided instrument support, repair, and calibration services as needed for the Anchor sites. The Field Manager and her staff also developed the operational procedures used at the Anchor sites. The Field Manager's staff responsibilities included the following:

- Develop a structured format for all routine checks performed on instruments to allow for consistency of operations.
- Develop or modify instrument SOPs for use at the Anchor sites. Most of the SOPs were drafted by the Measurement Experts for the Field Manager. The SOPs are included in Appendix A.
- Develop individual instrument Quick Reference Sheets and instrument worksheets. The Quick Reference Sheets specify the routine check and maintenance tasks, the frequency of the tasks, and the criteria for task performance. The instrument worksheets were used to document the results of the routine checks. Checks were performed daily, weekly, biweekly, monthly, or quarterly according to the needs defined in the SOPs.
- Develop daily and monthly schedules for the operators at each site. These schedules were designed to give site operators a guide for maintaining all the instruments at their site. The overall monthly schedules were based on the individual instrument schedules summarized in the Quick Reference Sheets.
- Provide training for all routine checks and maintenance performed on instruments.
- Provide support for non-routine troubleshooting of instrument malfunctions or failures.
- Review uploaded data on a daily basis and discuss findings with field technicians.
- Manage the schedules and activities of all field staff.
- Provide instrument repair and support services and quarterly external calibrations.
- Provide backup or substitute personnel for the site operators.

4.3 OPERATIONAL PROCEDURES AND DOCUMENTATION

This section provides examples of the procedures and documentation used during normal operations. The documentation for all sites and all instruments is archived at STI

4.3.1 Monthly Schedule

A monthly schedule of operations was compiled for every site that had a full-time, dedicated site operator. The schedule was intended to address the check and maintenance needs of each instrument and allow the operator time for unplanned troubleshooting. Note that for the remote sites a monthly schedule of operations was not completed because there was not a full-time, dedicated field technician. Field technicians visited these sites biweekly or monthly and completed all checks regardless of the frequency defined in the SOPs.

Because the instrumentation varied at each of the Anchor sites and varied for different study periods, the monthly schedule of operations was specific to the site and study period. **Table 4-1** illustrates an example monthly schedule for Angiola during the Annual Study period. The schedules provided decision-making guidance for the site operators. The directions to the operators that accompanied the schedules are listed below:

- **Estimated times** are in minutes unless otherwise noted.
- **The scheduled tasks** should not be rearranged. Please complete the specific tasks on the suggested days so that a rhythm is maintained and so that the STI data archivist can easily recognize your work in the data set.
- **In order to stay on schedule**, notify the field manager as soon as a problem arises that you do not know how to handle (before you spend time trying to troubleshoot the problem). The field manager will provide troubleshooting guidance but may ask for your help if you have free time in your schedule. Make sure you finish all of your tasks for the day besides checkout before providing assistance to the field manager.
- **Most days are scheduled to have a maximum of five hours of tasks.** This should allow you some flexibility to do some minor troubleshooting, spend some time on the phone, and spend time checking your e-mail. There is no way to estimate the time needed for this, but I allowed at least three hours of flex time in which I planned for you to do these things. The only days when there are more than five hours of tasks are days when the tower instruments will be lowered for audits and maintenance.
- **SFS sample cycles** occur every six days—these tasks have not been added to this list; however, the SFS filter needs to be changed out by the day prior to sampling. If sampling occurs on Saturday, Sunday, or Monday, the SFS filters need to be changed out by the Friday prior to sampling. This task takes approximately 30 minutes and is likely to occur twice a week.

4.3.2 Site Log

A site log was compiled for each site that had a full-time, dedicated site operator. This log allowed the field technician to summarize activities at and visits to the site on a daily basis. Note that for the remote sites, a site log was not compiled as there was not a full-time, dedicated field technician. At these sites, field technicians summarized all task results and site visits in the instrument logbooks.

Because the instrumentation varied at each of the Anchor sites and varied for different study periods, the site log was specific to the site and study period. **Table 4-2** is an example of the site log for Angiola annual operations. The following information was recorded daily on the site log by the field technician:

- General weather observations when site operator enters site,
- Instrument status and current measurement values when site operator enters and leaves site,
- Off-line and on-line times if an instrument was serviced, and
- Comments regarding any work done or observations over the course of the day.

4.3.3 Quick Reference Sheet

A Quick Reference Sheet was compiled for each instrument. This sheet summarized the routine checks and maintenance required for a particular instrument as described in the SOP. **Table 4-3** illustrates an example Quick Reference Sheet for the Andersen Instruments AE1X Single-Wavelength Aethalometer. The checks and maintenance are organized into tasks. For each task, the Quick Reference Sheet lists procedures and expected results or evaluation criteria, references to locate additional information in the instrument manual or SOP, information on troubleshooting in case the expected criteria are not met, and the expected time for the task to take. For most tasks, there was an accompanying worksheet that was used to document the results of the task. The goal of the Quick Reference Sheet was not to replace the SOP but to reorganize the operations described in it in a more concise format than allowed within the NARSTO SOP format.

4.3.4 Instrument Worksheets

Instrument worksheets were compiled to provide a consistent framework for documenting the results of the operational checks spelled out in the Quick Reference Sheets and to guide the site operators through the tasks. **Table 4-4** illustrates an example instrument worksheet for the weekly check performed on the Andersen Instruments AE1X Single-Wavelength Aethalometer.

4.3.5 Instrument Logbooks

Instrument logbooks were maintained for each instrument and were kept with the instruments. These logbooks were used to document activities involving the specific instrument. For activities included in the SOPs and Quick Reference Sheets, only the time of the activity and the result was recorded. Additional descriptions of the routine activities can be found in the SOPs.

The instrument logbooks were also used to document non-routine work to troubleshoot instrument malfunctions or failures. The procedures followed to do this troubleshooting were recorded in the instrument log along with the off-line and on-line times and the results of the troubleshooting. Special calibrations, off-site repairs, and transfers of instruments to new sites were also documented in the instrument logbooks.

4.3.6 Standard Operating Procedures

Standard operating procedures for each instrument were written by experts in the measurement technique. The procedures defined in these SOPs were tailored for CRPAQS and were discussed and approved by the STI Principal Investigator, Technical Coordinator, and Field Manager. These documents are written in the NARSTO format and provide detailed background, measurement technique, installation, routine operation, and troubleshooting information. SOPs for each instrument used in CRPAQS have been integrated into the QIWP and can also be found in Appendix A.

Table 4-1. Angiola monthly schedule during annual operations.

Week	Monday Neph, OPCs		**Tuesday** O_3, BAM		**Wednesday** NOy, OC/EC		**Thursday** Aeth		**Friday** Paperwork	
1	Check-in	15	Check-in	15	Check-in	15	Check-in	15	Check-in	15
	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2	30
	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	NOy Task 4	2h	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10
	Tower lower/raise	60	O_3 Tasks 3,4	20	O_3 Tasks 1,2	10	Aeth Task 1	45	Neph – getneph	5
	Neph Task 3 (for 4)	20	BAM Tasks 2,3	60	Neph – getneph	5	Aeth Tasks 2,3	2h	OPC 1, 2, 3	80
	Neph Task 4 (for 4)	2h	BAM Tasks 4,5	90	OPC 1, 2	35	Aeth Task 4	45	0-Air manual bleed	5
	Neph – getneph	5	Neph – getneph	5	Check-out (fSTI)	15	Neph – getneph	5	Check cyl (eBW)	10
	OPC 1, 2	35	OPC 1	15			OPC 1	15	Reset clocks	10
	Check-out (fSTI)	15	Check-out (fSTI)	15			Check-out (fSTI)	15	Timecard (mSTI)	30
									Inst. Logs (mSTI)	60
									Calib. Files (eBW)	15
									Check-out (fSTI)	15
	Total	5h	Total	4h	Total	4h	Total	5h	Total	5h
2	Check-in	15	Check-in	15	Check-in	15	Check-in	15	Check-in	15
	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2,3	45	NOy Tasks 1,2	30	NOy Tasks 1,2	30
	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10
	Tower lower/raise	60	O_3 Tasks 3,4	20	Neph – getneph	5	Aeth Task 1	45	Neph – getneph	5
	Neph Task 2 (for 4)	20	BAM Tasks 2,3	60	OPC 1, 2, 4	2h	Neph – getneph	5	OPC 1, 2, 3	80
	Neph Task 4 (for 4)	2h	Neph – getneph	5	Check-out (fSTI)	15	OPC 1	15	0-Air manual bleed	5
	Neph – getneph	5	OPC 1	15			Check-out (fSTI)	15	Check cyl (eBW)	10
	OPC 1, 2	35	Check-out (fSTI)	15					Reset clocks	10
	Check-out (fSTI)	15							Timecard (f,mSTI)	30
									Inst. Logs (mSTI)	60
									Calib. Files (eBW)	15
									Check-out (fSTI)	15
	Total	5h	Total	3h	Total	3h	Total	3h	Total	5h

Table 4-1. Angiola monthly schedule during annual operations.

Week	Monday Neph, OPCs		**Tuesday** O_3, BAM		**Wednesday** NOy, OC/EC		**Thursday** Aeth		**Friday** Paperwork	
3	Check-in	15	Check-in	15	Check-in	15	Check-in	15	Check-in	15
	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2	30
	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	NOy Task 4	2h	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10
	Tower lower/raise	60	O_3 Tasks 3,4	20	O_3 Tasks 1,2	10	Neph – getneph	5	Neph – getneph	5
	Neph Task 2 (for 4)	20	BAM Tasks 2,3	60	Neph – getneph	5	OPC 1	15	OPC 1, 2, 3	80
	Neph Task 4 (for 4)	2h	Neph – getneph	5	OPC 1, 2	35	Aeth Task 1	45	0-Air manual bleed	5
	Neph – getneph	5	OPC 1	15	Check-out (fSTI)	15	Check-out (fSTI)	15	Check cyl (eBW)	10
	OPC 1, 2	35	Check-out (fSTI)	15					Reset clocks	10
	Check-out (fSTI)	15							Timecard (f,mSTI)	30
									Inst. Logs (mSTI)	60
									Calib. Files (eBW)	15
									Check-out (fSTI)	15
	Total	5h	Total	3h	Total	4h	Total	2h	Total	5h
4	Check-in	15	Check-in	15	Check-in	15	Check-in	15	Check-in	15
	NOy Tasks 1,2	30	NOy Tasks 1,2	30	NOy Tasks 1,2,3	45	NOy Tasks 1,2	30	NOy Tasks 1,2	30
	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10	O_3 Tasks 1,2	10
	Tower lower/raise	60	O_3 Tasks 3,4	20	Neph – getneph	5	Neph – getneph	5	Neph – getneph	5
	Neph Task 2 (for 4)	20	BAM Tasks 2,3	60	OPC 1, 2, 4	2h	OPC 1	15	OPC 1, 2, 3	80
	Neph Task 4 (for 4)	2h	Neph – getneph	5	Check-out (fSTI)	15	Aeth Task 1	45	0-Air manual bleed	5
	Neph – getneph	5	OPC 1	15			Check-out (fSTI)	15	Check cyl (eBW)	10
	OPC 1, 2	35	Check-out (fSTI)	15					Reset clocks	10
	Check-out (fSTI)	15							Timecard (f,mSTI)	30
									Inst. Logs (mSTI)	60
									Calib. Files (eBW)	15
									Check-out (fSTI)	15
	Total	5h	Total	3h	Total	4h	Total	2h	Total	5h

Table 4-2. Angiola daily site log for annual operations.

Date/Time:	**Clouds?** Yes/No	**Fog?** Yes / No	**Visibility?** 50’ / 2miles / 10miles / 50miles	**Rain?** Yes / No
	Wind Speed? 0-5mph / 5-10mph / >10mph		**Wind Direction?** N / NE / E / SE / S / SW / W / NW	
FT:	**Other?**			

Inst (I)	**AM [b] I Value, I Unit, I Time/FT Time**	**Prob?**	**PM [b] I Value, I Unit, I Time/FT Time**	**Prob?**	**Offline Time**	**Online Time**	**Comments**
0Air- Gen [a]							
0Air Matrix [a]							
Calib [a]							
DAS [a]							
Minivol [a]							
SFS [a]							
Aeth							
BAM2.5							
BAM10							
Neph							
NOy							
OC/EC							
OPCs							
Ozone							

[a] No value needed.
[b] Use a stopwatch or your watch as a standard for all time checks.
[c] Call BW after the AM check if an instrument has a problem.

Table 4-3. Andersen Instruments AE1X Aethalometer Quick Reference Sheet.

Task		**Performance statistic**	**Section of SOP or Manual**		**Frequency**	**Time**	**Work-sheet**
			Additional task guidance	**Additional troubleshooting guidance** [1]			
1	**Weekly checks**						
	Check filter tape	No tears	Task 1	Check for obstructions along filter track.	Weekly	30-45 min	yes
		No overlapping or oddly shaped samples		Check for obstructions at the nozzle and optical chamber. Check the "Spots Per Advance" setting = 2 in the "Change Settings" menu.			
		Proper spooling of filter tape		Check that the take up reel sensor is not stuck in the "taught" (left most) position. Call ME.			
	Check flow rate	6.9 LPM +/- 10%		Check integrity of pump. Check for obstructions at cyclone, instrument inlet (back of instrument), and nozzle. Advance filter tape.			
	Check % tape remaining	> 10%		Load new filter tape.			
	Check disk remaining	> 10d		Load new disk, label used disk, and send to STI.			
	Print out error messages	N/A		N/A			
2	**Monthly checks**						
	Self test	All tests pass	Task 2, Manual 13.4	Call ME or FM.	Monthly	1 hr 10 min	yes
	Optical test strip procedure	Balance = 1 +/- 0.1	Task 2, Manual 13.7, 16.1	Strip should lay flat and flush against back of sensing region.		10 min	
	Dynamic zero check	0 +/- 0.4 ug/m^3	Task 2	Check for leaks through clean filter. Call ME.		30 min	
	Flow audit (at cyclone)	< 10% difference		Advance filter tape twice and check again. Check integrity of pump. Check for obstructions at cyclone, instrument inlet (back of instrument), and nozzle. Call ME or FM and re-calibrate flow meter [1].		20 min	
3	**Monthly maintenance**						
	Check inlet at cyclone for blockage	No blockages	Task 3	Check for obstructions at instrument inlet (back of instrument), and nozzle.	Monthly	5 min	yes
	Check vacuum pump filters.	Clean filters	Task 3, Gast Manual	Check integrity of pump.		10 min	
	Change diskette	N/A	Task 3	N/A		5 min	
4	**Bimonthly maintenance**						
	Change filter tape and clean stainless steel supporting mesh	N/A	Task 5, Manual 10, 13.8	N/A	Bimonthly or as needed	15 min	no
	Inspect pump diaphragm and head gasket for cracks or tears	Excessive wear	Task 5, Gast Manual	Replace as necessary. Call ME or FM if the wear is excessive.		30 min	
5	**Re-calibrate flow meter[2] and perform post calib audit**	< 10% difference	Task 4, Manual 13.5, 14	Advance filter tape. Check integrity of pump. Check for obstructions. Call FM and re-calibrate flow meter [2].	As needed	30 min	yes

[1] Key to abbreviations: FM = CRPAQS Field Manager
ME = CRPAQS BAM Measurement Expert

[2] The flowmeter should not be recalibrated without permission from the ME or FM.

Table 4-4. Andersen Instruments AE1X Aethalometer Task 1 Worksheet.

Instrument:	Anderson Instruments Aethalometer				
Worksheet:	Task 1 - Weekly checks (weekly)				
Site Code:					
Day of week					
Date	/ /	/ /	/ /	/ /	/ /
Field Tech					
Instrument SN					
INITIAL CHECKS:					
Time					
DAS clock (PST)	: :	: :	: :	: :	: :
Aethalometer clock (PST)	: :	: :	: :	: :	: :
Aethalometer statistics					
Filter remaining (%)					
Disk remaining					
Current BC value (ug/m^3)					
1.) WEEKLY CHECKS:					
Check filter tape					
Tears?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Overlapping or oddly shaped samples?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Proper spooling of filter tape?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Check instrument					
Visibly dirty?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Check flowrate on instrument panel					
Flowrate (LPM)					
6.9 +/- 1 (LPM)?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Compare flowrate with last flowrate check					
Date of last flowrate check	/ /	/ /	/ /	/ /	/ /
Difference since last check (LPM)					
Error messages					
Date of last error review	/ /	/ /	/ /	/ /	/ /
Reviewed all prior messages?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Errors or warnings?	Yes / No	Yes / No	Yes / No	Yes / No	Yes / No
Warning message					
Comments					

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5. QUALITY ASSURANCE AUDIT ACTIVITIES AND INSTRUMENT INTERCOMPARISONS

This section describes external quality assurance audit and intercomparison activities which were conducted to assess the quality of the measurements.

5.1 AUDIT ACTIVITIES

5.1.1 Summary of Audits

External audits were performed during the field study by David Bush of Parsons Engineering. Systems audits were performed to ensure that the installations were appropriate and that procedures were adequate to meet the data quality objectives, were well-documented, and were being followed. Performance audits were performed to assess the accuracy of the instruments and calibrations and to detect systematic problems in instrument setup and operation.

Audits were performed for nearly every site and instrument. For a few instruments, multiple audits were performed in different seasons. **Table 5-1** lists the audits done at each site and the seasonal study period they were intended to evaluate. If a system or performance issue that required resolution was identified during an audit, an indication is shown under the “Issues Identified?” column.

After each audit, the auditor discussed the system-audit findings and performance results with the STI Field Manager. Any issues that were raised were addressed immediately. In most cases, issues that were noted by the auditor were already in the process of being addressed. In a few cases, mostly associated with the grab samplers, the auditor identified issues that had not been recognized by the field staff.

Table 5-1. Audits performed at CRPAQS Anchor sites.

Site	Date of Audit	ID of Audited Instruments	Annual	Summer	Fall	Winter	Further Evaluation Required[a]
ALT1	2/7/01	K				X	K
ANGI	1/19/00	A, G-1, J, K, L, M, P	X				None
	4/18/00	H, O	X				O
	11/28/00	G-2, H, I-1, I-2, I-3, J, K, Q, V, X				X	J, K, V, X
	12/20/00	A, L, M, O, R, W, b, c, d, i, j				X	A, O
ANGT	10/23/00	A, I-1	X				I-1
	12/21/00	A, G-2, O, Q				X	None
BAC	1/20/00	A, G-1, J, L, M	X				None
	4/18/00	K, O, L,M	X				O, L, M
	10/24/00	O, b	X				None
	11/27/00	A, G-2, H, J, K, L, M, Q, Y				X	Q
BODB	None						
BTI	12/1/00	A, G-2, K, L, M, O, Q, U, V, X, b				X	G-2, K, V
	12/15/00	W				X	None
COP	10/23/00	A, G-2, J, K, Q			X		J, K
EDW	None						
M14	2/6/01	G-1				X	G-1
SDP	2/7/01	G-2, K, BIOS				X	K, BIOS
SJ4	2/8/01	A, G-2, K, Q, BIOS				X	K, BIOS
SNFH	11/30/00	O, R, b, Met sensor				X	R, Met sensor
	12/1/00	G-2, K, P, Q, U, V, X				X	V
	12/15/00	L, M, W, i, j				X	i, j
WAG/ WAGT	None						

[a] Additional information is provided in Section 5.1.2.

5.1.2 Summary of Audit Findings

The system and performance issues identified by the auditor are summarized below. The issues are described, and the approach used to address the issues is discussed.

<u>Siting – M14, February 6, 2001</u>

The auditor pointed out that the M14 Aethalometer measurement might be influenced by emissions from an air conditioning duct 1 m from the inlet. The M14 BAAQMD site operator was contacted to confirm whether the air conditioner was in use during the Winter Study. The air conditioning system turned out to be an electric heat pump which operates year around but which emits only heated or cooled ambient air from the heat exchanger.

Cal – BIOS primary flow standard – SDP, February 7, 2001; SJ4 February 8, 2001

The auditor compared the BIOS primary flow standard used at SDP and SJ4 to his external primary flow standard and found a discrepancy. The auditor suggested that the site standard be recalibrated and questioned the accuracy of the flow standard used for SJ4 and SDP site checks. Upon further investigation of the accuracy of this standard relative to the standards used at ANGI, no notable problem was found. From subsequent discussion with users of the BIOS flow standard and the Gilibrator standard used as an alternate, it appears that the two standards vary as much as 10%, with the BIOS reading lower. No corrective action was taken because the reason for the differences was not determined. Data were reported as valid if instruments calibrated with either standard were within 10% of their nominal flow rate. If flow rates were from 10% to 20% off, data were labeled as suspect, and for discrepancies greater than 20%, data were considered invalid.

The BIOS flow standard was used for BAM and Aethalometer flow checks at SDP, SJ4, and ALT.

Method A – Light Scattering with Radiance Research M903 Nephelometer – ANGI, December 20, 2000

The time constant (tc) value was found to differ from the tc value observed on the other CRPAQS nephelometers. Because all averaging and time constant settings were sensible and consistent with those from other nephelometers, this was considered to be an electronic glitch.

Method G – $PM_{2.5}$ Black Carbon with Andersen Instruments AE3X Aethalometer – BTI, December 1, 2000

The Aethalometer flow rate measured at the inlet was found to be 10% higher than the flow rate indicated on the instrument display panel. The field technician checked the flow rate using the onsite primary flow standard and determined that the flow rate was 5% high. No action was taken because the flow rates determined by either method were within the 10% threshold for valid data.

Method I-1 – Particle Sizing with Climet CI-500 – ANGT, October 23, 2000

The transport flow through the instrument inlet was found to be high and out of specification. This audit finding raised a concern about the transport flow system setup. The transport flow system was not stable. The flow was controlled by a rotameter that was sensitive to vibration, and the settings would eventually drift. To address this issue, the flow rate through the inlet was checked and adjusted more frequently. After this audit, the flow rate through the inlet was well-controlled and no longer a problem.

Methods J, K – $PM_{2.5}$/PM_{10} Mass with Met One Instruments 1020 BAM – ALT, February 7, 2001; ANGI, November 28, 2000; BTI, December 1, 2000; COP, October 23, 2000; SDP, February 7, 2001; SJ4, February 8, 2001

Minor sampling leaks around the nozzle of the instrument were observed at ALT, ANGI, and COP. The leak magnitudes were well within performance specifications and, as a result, were not considered to be a problem. Leaks tended to occur when the RH was high and small pieces of filter tape would stick to the nozzle, preventing a good seal on the next sampling spot on the tape. Larger leaks were experienced at SDP. Even after cleaning the nozzle, the SDP BAM flow rates were about 10% below the target flow rate.

A major nozzle leak was also observed at BTI. Upon investigation, it was found that this leak was caused by an installation problem. The inlet needed to be repositioned to minimize torque on the nozzle to allow free movement of the nozzle during routine operation. The problem was repaired and was not observed again.

During the February 8, 2001, audit at SJ4, the BAM flow rate was found to be 24% high. A review of the software setting revealed an incorrect setting. After resetting, the audit was within specifications. We examined the field notes and found that the flow rates were within specifications during checks on the morning of the audit and the month before. The same site calibrator was used to recheck the flow the day after the audit, and the flow rate was found to be proper. We concluded that the setting must have been inadvertently changed during the flow check prior to the audit or at the beginning of the audit, and data for the few hours between the flow check and the audit were invalidated.

Methods L, M – $PM_{2.5}$ Mass & Elements/Ions & Carbons with SFS – BAC, April 18, 2000

An inconsistency in operational procedures was noted at BAC. DRI verbally requested that “make-up” flows be measured periodically at ANGI. These same instructions were not verbally given during the training at BAC. After this systems audit observation was made, the BAC site operator began measuring this flow as requested. DRI was not concerned about the lack of this information up to this point but was interested in having the flow be measured from this point on.

Method O – NO_y with Thermo Environmental 42C/Y – ANGI, April 18, 2000; ANGI, December 20, 2000; BAC, April 18, 2000

During both the April 18, 2000 and the December 20, 2000 audits at ANGI, it was noted that the converter efficiency was lower than acceptable. During the study, converter efficiencies at this site continually dropped, and converters were replaced nearly monthly. It became clear that there was a problem in the converters being supplied by TEI. CE-CERT advised that the converters should no longer be replaced, due to the ineffectiveness of the replacement. Instead, they advised that the converter efficiency be frequently evaluated in order to track the decline of the converter. Converter efficiencies appeared to vary both up and down from test to test. At the end of the study, CE-CERT advised not correcting for converter efficiency unless the efficiency was less than 85%. It turned out that over 90% of the measurements had converter efficiency above 85% and that most of the rest of the data were invalidated for reasons not associated with the converters, so no adjustments were made for converter efficiency.

At ANGI on December 20, 2000, the gas-phase instrument response was noted to be out of specification when compared to a transfer standard. This audit was performed using the instrument values entrained into the data system. These values were not adjusted yet for calibration, and it was the policy of the CRPAQS Anchor site management team to not adjust the instrument response after installation of the instrument. Instead the instrument response relative to the STI transfer standard was tracked for the purposes of data post-processing. As a result, no corrective action was taken.

At both the ANGI and BAC audits on April 18, 2000, the auditor noted a reduction in the flow through the NO_y channel relative to the NO channel. This performance result was addressed by investigating a possible leak in the system. No leak was found, and it was concluded that the NO_y inlet filter was possibly clogged and in need of replacement. Because no information was available to support or refute this, and flows appeared reasonable after the audit, no further action was taken. During the Winter Study, a similar observation was made by the STI Field Manager. At that time, the observation was the result of a clogged filter.

Method Q – $PM_{2.5}$ Nitrate with Rupprecht & Patashnick 8400N – BAC, November 27, 2000; COP October 23, 2000

The audit performed at BAC on November 27, 2000, revealed that the sample flow rate displayed on the nitrate instrument panel was low relative to the audited flow rate. The difference in flow rate was considered to be acceptable.

The systems audit performed at COP on October 23, 2000, revealed that performance criteria were not clearly stated in the SOP. ADI was contacted and the performance criteria were made clearer. The field technicians were advised of the new information.

At COP, the NO response of the NO monitor was low relative to the external transfer standard. This performance result was discussed with ADI. ADI advised that this audit finding required no corrective action because the nitrate measurement is made from the change in response of the NO monitor and not the absolute value of the NO response.

Method R – HNO_3 with Thermo Environmental Dual Converter 42C/Y – SNFH November 30, 2000

This instrument was only operated for the Winter Study. The auditor found that the data system had not been set up to correctly collect data from the instrument. A modification to the data system settings file (.ini file) was made to rectify the problem on the same date as the audit. This was not a problem because raw data files were recorded as a backup, and because the problem was discovered before the start of the Winter Study.

Method V – Heavy Hydrocarbons with TENAX - ANGI November 28, 2000; BTI December 1, 2000; SNFH December 1, 2000

The audit at ANGI revealed that the mass flow meter provided with the TENAX sampler was 17% low relative to the audit standard. Because the field technician recorded flow rate using the provided flow meter and the flow meter was owned by DRI, this audit finding was communicated to DRI. It was assumed that DRI had characterized the flow meter and would take the observed difference into account in post-processing.

The SNFH audit revealed a design flaw in the second TENAX sampler provided for this site. It did not appear to be originally designed for TENAX sampling. A similar flaw was observed in the second sampler provided for BTI although this problem was not noted by the auditor. DRI was contacted and the field technicians worked with DRI to modify the way the substrate was loaded into the second sampler. By the second episode, all problems had been resolved.

At all three sites, the auditor noted that the TENAX procedures were unclear. STI worked with DRI to refine the procedures by the end of the first episode day.

Method X – Aldehydes with DNPH – ANGI, November 28, 2000

This ANGI audit revealed a sampler solenoid valve malfunction. This problem was also observed at BTI and SNFH, although it was not noted by the auditor. The field technicians worked with AtmAA to repair the samplers. By the second episode, all problems had been resolved. Because the problems were resolved, additional procedures to monitor solenoid function were not instituted.

Methods I, j – Denuder HNO_3/NH_3 with SGS – SNFH, December 15, 2000

When the filter packs were removed from the sampler for the audit, a significant amount of debris was observed on the filters. The sampler plenums were inspected and no debris was observed. The field technician noted that the debris might have come from contact of the substrate with the ground. He modified his sampler loading procedures to make sure that substrates were handled with greater care, and monitored the plenum and substrates for future contamination. The field technician also noted the contamination on the sampler chain of custody form. By the end of the first episode day, all SGS sampler contamination problems had been resolved.

Met station (SNFH December 15, 2000)

The auditor found that the anemometer was misaligned by 15° from true north. This misalignment should be accounted for in data processing.

5.2 INSTRUMENT INTERCOMPARISONS

5.2.1 Overview

Instruments of the same make and model should perform similarly and within the specifications described in the SOPs and the data qualification statements. Even so, it was desirable to quantify the precision and biases of concentration measurements between collocated similar instruments for three purposes.

First, instruments mounted at multiple elevations on the Angiola and Walnut Grove Towers were installed to measure vertical concentration gradients, and these gradients are often small. For these instruments, it is essential to understand the precision of collocated measurements in order to quantify the smallest vertical concentration differences that could be measured when the instruments were separated. These instruments included the Aethalometers, nephelometers, nitrate monitors, and the Climet OPCs.

Second, in the case of the Aethalometers, the 1-wavelength and 7-wavelength instruments were assumed to make comparable measurements, at least for the overlapping wavelength, even though there were design differences between the two instruments. Because the two models were operated at different sites and we wanted to identify differences in concentration between the sites, it was important to determine the comparability of collocated measurements made by the two types of instruments. By determining the differences expected between collocated measurements, we can estimate the smallest differences that could be detected between sites.

Third, the Aethalometers, nephelometers, and BAMs were operated in different configurations or with different settings during the study. For the Aethalometers and nephelometers, it was important to identify biases or changes in instrument response between the differing configurations so that concentration differences between sites or seasons could be distinguished from differences due to configuration biases. $PM_{2.5}$ and PM_{10} BAMs were collocated at four sites during the study. For the BAMs, it was necessary to quantify the precision of measurements with identical inlets so that we could determine the smallest meaningful PM_{10}-$PM_{2.5}$ concentration differences that could be detected with different inlet cut points.

With the exception of the collocation of two BAMs at Bakersfield, all collocated-instrument comparisons were performed at the Angiola site. For these comparisons, the instruments were located in (or on) the measurement trailer at the Angiola site, on the Angiola tower, or in the CRPAQS site in Bakersfield. The nitrate monitors and optical particle counters used a shared inlet so that the collocated instruments sampled from the same gas stream through the same cyclone. All other instruments were set up to run identically but had independent inlets.

Table 5-2 lists the instrument types, the sites the instruments came from, the purposes of the intercomparisons, and the dates for the various comparisons performed. Additional descriptions of the comparisons are provided in the following subsections. The results of the comparisons are not included in this report. The comparison data will be analyzed as part of the CRPAQS data analysis effort.

Table 5-2. Instruments involved in intercomparison studies.

Site	ID	Instrument	Dates (2001)	Comparison type		
				Precision	Design Differences	Instru. Config.
ANGI	G-1	Aethalometer 1-wavelength	2/26-3/29		X	
ANGI	G-2	Aethalometer 7-wavelength	2/26-3/29	X	X	X
ANGT	G-2	Aethalometer 7-wavelength	2/26-3/29	X		X
ANGI	K	BAM $PM_{2.5}$	2/16-3/20	X		
ANGI	J	BAM PM_{10}	2/16-3/20	X		
BAC	K	BAM $PM_{2.5}$*	2/16-3/13	X		
BAC	J	BAM PM_{10}*	2/16-3/13	X		
ANGI	A	Nephelometer (revised configuration)	3/2-3/29 on trailer	X		X
ANGT	A	Nephelometer 1 m (original configuration)	3/2-3/29 on trailer	X		X
ANGT	A	Nephelometer 50 m (original configuration)	3/2-3/29 on trailer	X		X
ANGT	A	Nephelometer 95 m (revised configuration)	3/5-3/29 on trailer	X		X
ANGI	Q	Nitrate	2/8-2/25	X		
ANGT	Q	Nitrate 95 m	2/8-2/25	X		
ANGI	I-1	Optical particle counter	2/10-2/16	X		
ANGT	I-1	Optical particle counter 50 m	2/10-2/16	X		
ANGT	I-1	Optical particle counter 95 m	2/10-2/16	X		

* These instruments were compared at Bakersfield

5.2.2 Aethalometer Comparisons

The following black carbon instruments were included in intercomparison experiments on the ground at the Angiola site:

- Angiola ground 1-wavelength – Andersen Instruments AE1X SN229:32U2
- Angiola ground 7-wavelength – Andersen Instruments AE3X SN257:67P2
- Angiola tower 7-wavelength – Andersen Instruments AE3X SN254:40G6

The first two instruments were collocated to investigate the effects of design differences, and the second and third instruments were collocated to investigate precision for gradient measurements and biases due to instrument configuration. Additional information on the three Aethalometer comparisons is provided below.

Precision measurement

For this experiment, the two 7-wavelength instruments were set up in close proximity to each other inside the ANGI trailer. They had independent inlets and cyclones and used identical settings, including the 10X tape-saver feature.

Design differences

The single- and multi-wavelength models of the Andersen Instruments Aethalometer were used at different sites and in some cases at the same site at different times. The two models differ in optical chamber design and software. Initially this measurement was made at all sites using the 1-wavelength instruments. However, 7-wavelength instruments became available for the Fall and Winter studies and were distributed to the Annual Anchor sites (ANGI, BAC, SDP, and SJ4) and two of the new Winter Anchor sites (BTI and SNFH), as well COP for the fall. Single wavelength instruments were moved to the remaining anchor sites for the Winter Study. Because of the interchange of these two configurations of the same instrument, it was important to characterize differences in instrument response between the two models.

For this experiment, two ground-level instruments (one 1-wavelength and one 7-wavelength) were set up in close proximity to each other inside the ANGI trailer. They had independent inlets and cyclones and used identical settings, including the 10X tape-saver setting

Instrument configuration

During the Fall Study, PM concentrations increased, and Aethalometer tape advances occurred more frequently (often once an hour for the 7-wavelength instruments). Also, the tape advance process for the 7-wavelength instruments took up to 20 minutes (compared to 10 minutes for the 1-wavelength instruments). As a result, 75% data recovery was not achieved within the hours when a tape advance occurred, causing many hours of data to be below the threshold for acceptable data recovery. To alleviate this problem, the 7-wavelength instruments were reprogrammed to advance the tape in 10 minutes, and the tape-saver function was implemented during the Fall Study for both types of instruments. This function set the instruments so they would sample for a total of only 6 seconds out of each minute (compared to the normal 30 seconds), thus reducing the frequency of tape advances by a factor of 5. During the prior annual portions of the study, this function was not used because PM concentrations were more moderate, and only 1-wavelength instruments (which have fewer tape advances) were used, so data recovery was not impaired by frequent tape advances. The tape saver function reduced the frequency of tape advances and improved data recovery to within acceptable bounds.

For this experiment, the two 7-wavelength instruments were set up in close proximity to each other, with independent inlets and cyclones. One instrument used the original “NO SAVER” setting and the other instrument used the “10X SAVER” setting.

5.2.3 BAMs

The following BAMs were included in intercomparison experiments:

- Angiola ground $PM_{2.5}$ BAM – Met One Instruments BAM 1020 SNx4152
- Angiola ground PM_{10} BAM – Met One Instruments BAM 1020 SNx4619
- Bakersfield $PM_{2.5}$ BAM – Met One Instruments BAM 1020 SNx5217
- Bakersfield PM_{10} BAM – Met One Instruments BAM 1020 SNx4153

The first two instruments were collocated at ANGI and the second two instruments were collocated at BAC. Both comparisons were intended to investigate the precision that can be expected when using comparable inlets so that the lowest detectable differences using different inlets can be determined.

<u>Precision measurement (related to instrument configuration)</u>

At the ANGI, BAC, COP, and EDW sites, two Met One BAM 1020 instruments with different inlets were operated side by side to obtain a PM_{10} and a $PM_{2.5}$ mass measurement. The PM_{10} mass measurement was achieved by using only a dichot head inlet. The $PM_{2.5}$ mass measurement was achieved by using a Sharp-Cut cyclone in series with a dichot head inlet. In order to identify the smallest differences that could be distinguished between the PM_{10} and $PM_{2.5}$ mass measurements, it was necessary to measure the precision of the instruments when they sampled identically (i.e., both instruments set up to measure PM_{10} mass).

For this experiment, the instruments were set up in close proximity to each other, with identical settings and independent inlets. At both sites, the two BAMs were set up to sample only through the dichot head inlet (for the $PM_{2.5}$ BAMs, the $PM_{2.5}$ sharp-cut cyclone adapters were removed).

5.2.4 Nephelometers

The following light scattering instruments were included in intercomparison experiments on the ground at the Angiola site:

- Angiola trailer nephelometer – Radiance Research M903 SN0262
- Angiola 1 m tower nephelometer – Radiance Research M903 SN0194
- Angiola 50 m tower nephelometer – Radiance Research M903 SN0192
- Angiola 95 m tower nephelometer – Radiance Research M903 SN0193/
- Replacement for SN0193 after malfunction - Radiance Research M903 SN0276

Four instruments were collocated at ANGI to investigate instrument precision and the effects of instrument configuration on the measurements.

Precision measurement

Understanding the precision achievable by multiple instruments is important for this measurement because of the desire to compare light scattering measurements at multiple elevations at both the ANGT and WAG/WAGT sites. At WAG, nephelometers were operated at 10 m and 245 m. Both instruments were installed to sample ambient PM from within an enclosure. This is the typical sampling configuration of the nephelometers used during CRPAQS. At Angiola, nephelometers were operated at about 7 m on the trailer and at 1 m, 50 m, and 95 m on the tower. The 7-m and 1-m instruments sampled and vented from within the enclosure, and a fan drew ambient air into and out of the enclosure (typical configuration). The 50-m and 95-m instruments sampled ambient air through an aluminum inlet and vented outside the enclosure through a fan (atypical configuration). This atypical installation was necessary because of the presence of other instruments in the 50-m and 95-m enclosures.

The precision of measurements using the same types of inlets and enclosures was explored in two ways. First, the 50-m and 95-m instruments were lowered to near ground level and operated in close proximity to compare two systems each operated in tower enclosures. (The 1-m tower nephelometer was also operated at the same time, so the bias between the tower enclosures and the standard enclosures could be determined as well.) In addition, at the end of the study, the three tower nephelometers and the ANGI nephelometer were all collocated on the roof of the trailer in proximity to the ANGI 4-m nephelometer. All four instruments were installed in individual standard enclosures to sample ambient PM in the typical fashion. This experiment is described by Richards (2002), which is included in Appendix A.2.

Instrument configuration

Two experiments were performed. The first experiment investigated measurement biases resulting from the difference in instrument inlet and enclosure configuration (typical vs. atypical). As noted above, the 1-m tower nephelometer was operated in the standard enclosure at the same time that the 50-m and 95-m instruments were operated with their enclosures at ground level, so the bias between the tower enclosures and the standard enclosures could be determined.

The second experiment was performed to investigate the effects of an instrument configuration change that occurred during the middle of the Winter Study. The instrument configuration was changed by reversing the flow through the instrument, keeping the heater upstream of the instrument, and by insulating the full body of the instrument. This change resulted in the RH sensor that controlled the heater being downstream of the sampling chamber and ensured that the RH in the sampling chamber was maintained below the RH set point (about 70%). In the original configuration, it was possible for the heated air to cool again after entering the sampling chamber and for the RH to increase above the set point. For this experiment, the configurations of two of the four instruments used for the precision experiment on the trailer roof were changed so that two instruments had the original inlet configuration and two had the modified inlet configuration. This experiment is also described in Richards (2002).

5.2.5 Nitrate Monitors

The following $PM_{2.5}$ nitrate instruments were compared at ground level at the Angiola site:

- Angiola ground nitrate – Rupprecht & Patashnick 8400N SN105
- Angiola 95 m tower nitrate – Rupprecht & Patashnick 8400N SN101

Precision measurement

Understanding the precision achievable by multiple instruments is important for this measurement because of the desire to compare nitrate measurements at the tops and bottoms of the Angiola and Walnut Grove towers. For this experiment, the ANGI sulfate instrument was removed from the trailer and the ANGT tower nitrate put in its place. The two nitrates shared a common inlet but used independent pumps and independent gas cylinders for operations. Both instruments used identical settings (as they did during normal operation).

5.2.6 Optical Particle Counters

The following OPCs were featured in intercomparison experiments on the ground and at 95 m at the Angiola site:

- Angiola ground optical particle counter – Climet Instruments CI-500 SN990246
- Angiola 50-m tower optical particle counter – Climet Instruments CI-500 SN978182
- Angiola 95-m tower optical particle counter – Climet Instruments CI-500 SN990247

All three instruments were collocated to investigate the precision achievable by multiple instruments under both indoor and tower conditions.

Precision measurements

Measurement of the precision was necessary to determine the minimum particle count differences detectable between instruments at multiple elevations on the ANGT tower. During normal operation, the ANGI ground instrument sampled ambient PM through a single PM_{10} dichot head and a manifold that fed the suite of particle sizing instruments. The PM_{10} dichot head required a total flow rate of 16.7 lpm to achieve its cutpoint, but the particle sizing system required only approximately 2 lpm to feed the instruments. To accommodate this difference in flow rate, a transport flow system was used. The ANGT tower instruments were operated at 50 m and 95 m. The tower instruments did not sample through manifolds but still sampled through PM_{10} dichot heads. As a result, a similar transport flow system was needed for each of these instruments.

Two different collocation tests were performed because of the sensitivity of these instruments to their operating environment and the minimally controlled environment of the tower enclosures relative to the trailer. In the first experiment, all three optical particle counters were installed in the 95-m enclosure and shared a single PM_{10} dichot head inlet and transport flow system. All three instruments were run side by side at the 95-m position to determine precision achievable in the outdoor tower operating environment. For the second experiment, the two tower instruments were installed in the trailer alongside the suite of particle sizing instruments to sample ambient PM from the manifold that fed the particle sizing system. The second experiment was performed to see if the precision was improved in a temperature-controlled environment.

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6. GUIDE TO ADDITIONAL INFORMATION

Additional documentation is available to help interpret CRPAQS field study data. Some of this information is informal field documentation. Other documentation is in the form of reports submitted to the ARB by STI and other contributors. Informal field documentation relevant to the Anchor sites has been archived at STI and is available upon written request. The reports submitted to the ARB will be available on the CRPAQS web site at http://www.arb.ca.gov/airways/crpaqs/publications.htm.

6.1 FIELD DOCUMENTATION

Informal instrument and site documentation was compiled during the field project as a means to track instrument performance and site activities. This information was subsequently used during data processing. Relevant information from this documentation has been integrated into this Field Report.

6.1.1 Instrument Documentation

The instrument documentation includes:

- Logbooks and worksheets which were compiled for each instrument by the field technician responsible for the instrument. These logs detail specific checks, maintenance, and troubleshooting performed on the instruments. They are raw in form.
- Off-line summaries which were compiled from the logbooks and worksheets for each instrument by the field technician responsible for the instrument and reviewed by the STI Field Manager. These summaries document when the instruments were on-line and off-line, note changes in instrument responses to calibration checks, and list events or activities that might affect the instrument responses. Activities that did not result in a change of instrument response are not listed in these summaries.
- Calibrations of instruments and transfer standards which were documented on calibration sheets and summarized for each instrument for use in data processing.

6.1.2 Site Documentation

Site documentation was prepared by both STI and ENSR. The ENSR documentation has been submitted as a report (see Section 6.2). STI site documentation includes the following:

- Layouts of the sites were sketched by the field technicians responsible for the sites. Critical dimensions including inlet heights, inlet spacing, and nearby obstructions or local sources are detailed on these sketches.
- Photos of the actual installations and surrounding area were also compiled for each site. Selected photos are included in this report.
- Directions from major highways to each site were compiled.

- Site logs were maintained at all sites with a full-time field technician. The on-site field technician completed this log on a daily basis. This log summarized weather conditions and instrument checks and maintenance.

6.2 REPORTS

CRPAQS Anchor Site planning, field operations, and data processing activities are documented in reports submitted to the ARB. Reports relevant to STI's Anchor-site activities include the following.

Planning

- Aerometric Monitoring Program Plan for the California Regional $PM_{2.5}/PM_{10}$ Air Quality Study (Watson et al., 1998)
- A Proposal for the California Regional $PM_{2.5}/PM_{10}$ Air Quality Study (STI 798900)

Operations

- Quality Integrated Work Plan for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study Continuous and Filter Air Quality Measurements (Wittig et al., 2000)
- Health and Safety Plan for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (Wittig et al., 1999)
- Audit Reports were prepared by the CRPAQS Quality Assurance Manager. These reports summarize the system findings and performance results and include the numerical results of each audit.
- California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRAPQS), Introduction to Site Documentation Reports (McDade, 2002). This ENSR document includes not only an introduction to the site reports, but also descriptive information, photos, site diagrams, and maps for each site.

Data Processing

- California Regional $PM_{10}/PM_{2.5}$ Air Quality Study, Management of Anchor Site Data (Hafner et al., 2003). This report describes the data processing procedures and includes a guide to the Anchor site data archive.
- Data Quality Summary Reports were compiled for each measurement type and include data quality objectives (when specified) and the achieved data quality metrics including accuracy and precision estimates and data completeness (Hyslop et al., 2003).

7. REFERENCES

Wittig A.E., Blumenthal D.L., Roberts P.T., and Hyslop N.P. (2003) California Regional $PM_{10}/PM_{2.5}$ Air Quality Study anchor site measurements and operations. Final report prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, Sonoma Technology, Inc., Petaluma, CA, STI-999231-2332-FR, May.

Hyslop N.P., Brown S.G., Gorin C.A., and Hafner H.R. (2003) California Regional $PM_{10}/PM_{2.5}$ Air Quality Study data quality summary reports. Final report prepared for San Joaquin Valleywide Air Pollution Study Agency, c/o California Air Resources Board, Sacramento, CA by Sonoma Technology, Inc., Petaluma, CA, STI-999242-2310-FR, February.

McDade C.E. (2002) California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRPAQS) introduction to site documentation reports. Draft report prepared for California Regional $PM_{10}/PM_{2.5}$ Air Quality Study Technical Committee, California Air Resources Board, Sacramento, CA, by ENSR International, Camarillo, CA, February.

Richards L.W. (2002) Analysis of data from the collocated operation of four Radiance Research nephelometers at Angiola after the end of the CRPAQS field study. Report prepared for The San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, by Sonoma Technology, Inc., Petaluma, CA, STI-999213-2292, December (revised).

Technical and Business Systems, Inc. (2002) Satellite network operations for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study (CRAPQS). Draft report prepared for the San Joaquin Valleywide Study Agency and the California Air Resources Board, Sacramento, CA, by T&B Systems, Inc., Santa Rosa, CA.

Watson J.G., DuBois D.W., DeMandel R., Kaduwela A., Magliano K., McDade C., Mueller P.K., Ranzieri A., Roth P.M., and Tanrikulu S. (1998) Aerometric monitoring program plan for the California Regional $PM_{2.5}/PM_{10}$ Air Quality Study. Draft report prepared for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study Technical Committee, California Air Resources Board, Sacramento, CA, by Desert Research Institute, Reno, NV, DRI Document No. 9801.1D5, December.

Wittig A.E., Hyslop N.P., and Roberts P.T. (1999) Health and safety plan for the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study. Prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, Sonoma Technology, Inc., Petaluma, CA, STI-999215-1894-HASP, September.

Wittig A.E., Hyslop N.P., and Roberts P. (2000) Quality integrated workplan for the continuous and filter air quality measurements in the California Regional $PM_{10}/PM_{2.5}$ Air Quality Study. Prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, by Sonoma Technology, Inc., STI-999214-1921-QIWP, April.

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